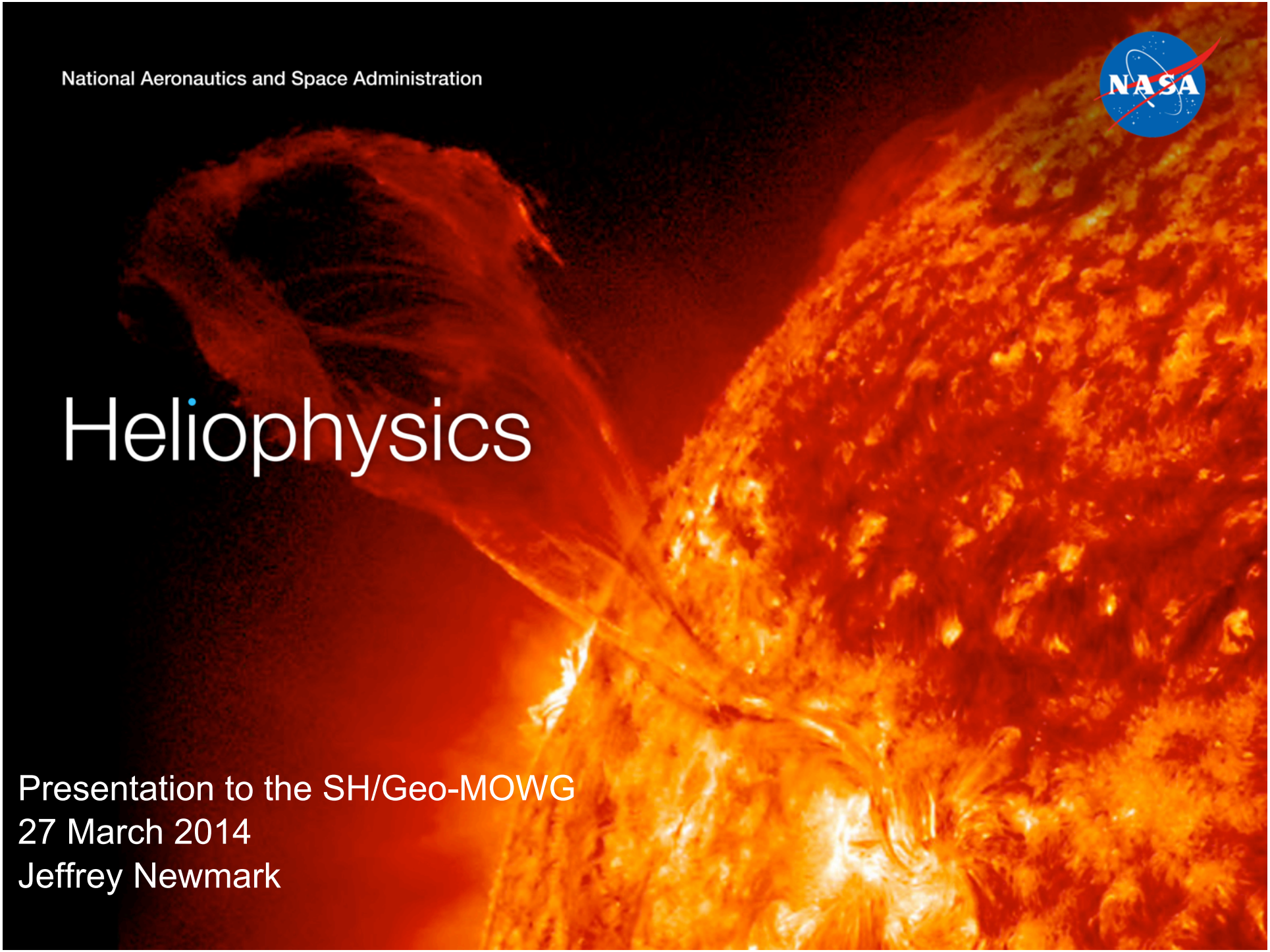

National Aeronautics and Space Administration
NASA
Heliophysics
Presentation to the SH/Geo-MOWG
27 March 2014
Jeffrey Newmark

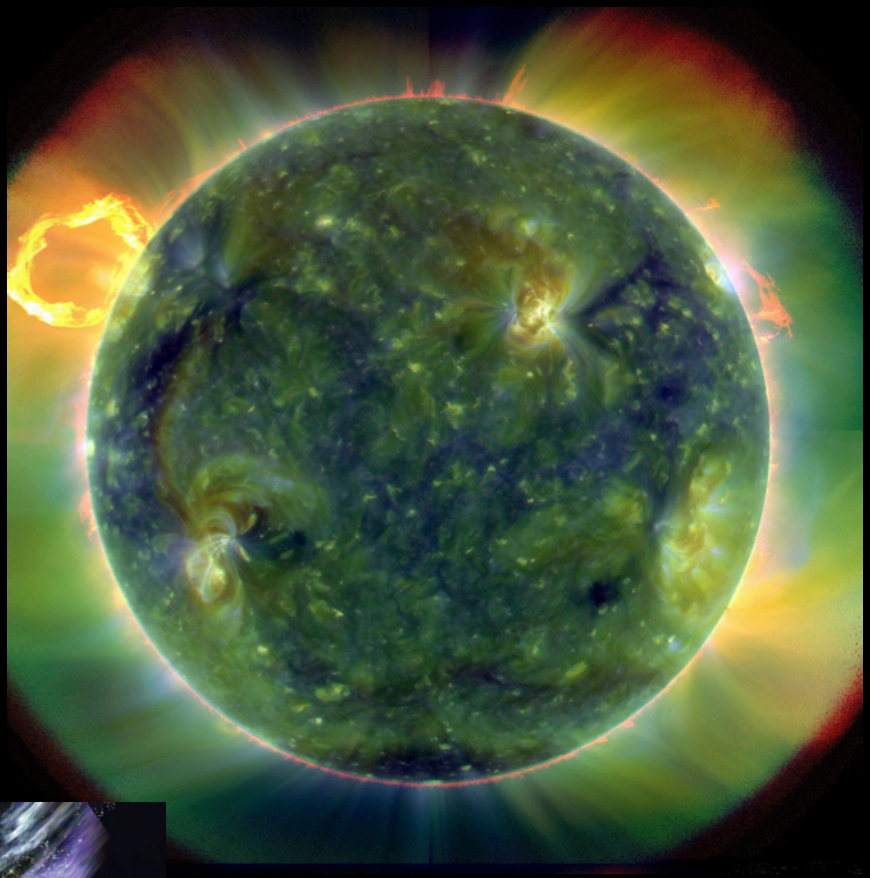
Topics for discussion

- **NASA's Heliophysics Division Objectives and Organization**
- **Recent Accomplishments, Program Updates, Current Status**
- **Heliophysics Budget Allocations and Projections**
- **Future Planning and Status of Decadal Survey Implementation**
- **Upcoming Key Events, Issues, Discussion**

NASA Heliophysics Science Objective

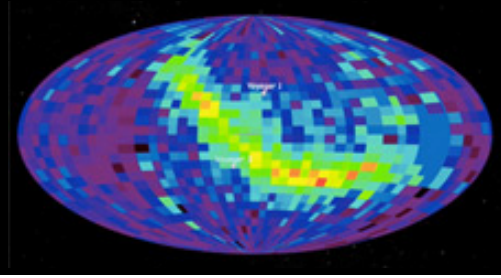
Understand the Sun and its interactions with the Earth, the Solar System, including space weather.

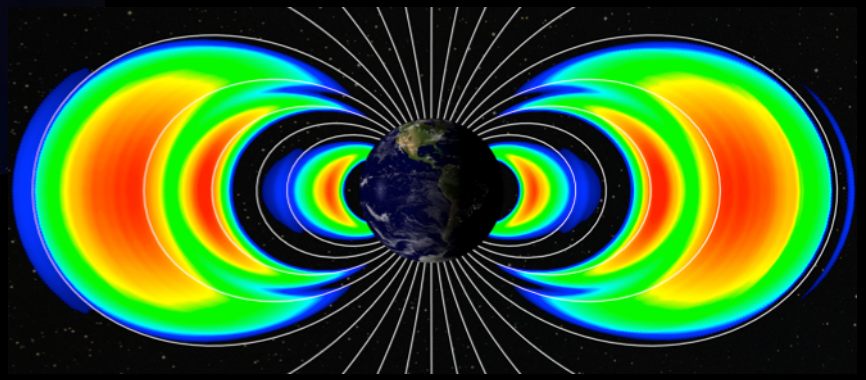
Solve the Fundamental Mysteries of Heliophysics



Understand the Nature of our Home in Space

Build the Knowledge to Forecast Space Weather Throughout the Heliosphere





HPD is Organized into Four Major Sections

Goal: Understand the Sun and its interactions with Earth and the solar system, including space weather

Solar Terrestrial Probes

Strategic Mission Flight Programs

Living With a Star

Strategic Mission Flight Programs

Solve the fundamental physics mysteries of heliophysics: Explore and examine the physical processes in the space environment from the sun to the Earth and throughout the solar system.

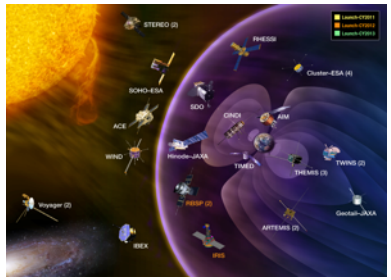
Build the knowledge to forecast space weather throughout the heliosphere: Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Understand the nature of our home in space: Advance our understanding of the connections that link the sun, the Earth, planetary space environments, and the outer reaches of our solar system.

Explorers

Smaller flight programs, competed science topics, often PI-led

Research



Scientific research projects utilizing existing data plus theory and modeling

2014 SMD Science Plan for Heliophysics

Topics for discussion

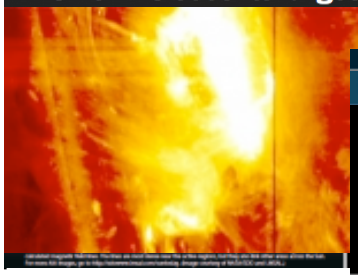
- **NASA's Heliophysics Division Objectives and Organization**
- **Recent Accomplishments, Program Updates, Current Status**
- **Heliophysics Budget Allocations and Projections**
- **Future Planning and Status of Decadal Survey Implementation**
- **Upcoming Key Events, Issues, Discussion**

Heliophysics Press Highlights

Productive scientific community, significant public impact.

The Washington Post

NASA's IRIS sees its largest solar flare



Sun Scientists Debate Whether Solar Lull Could Trigger Another 'Little Ice Age'

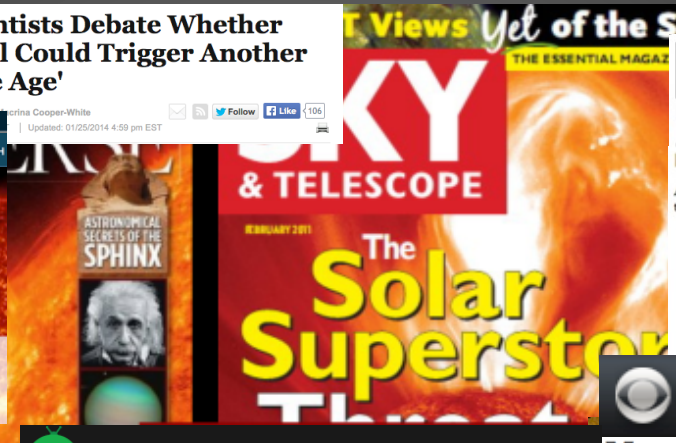
Updated: 01/25/2014 4:59 pm EST

SPACE

NBC NEWS HOME LATEST SEARCH

Huge Solar Flare Delays Private Rocket Launch to Space Station

BY TARIQ MALIK, SPACE.COM



DISCOVER MAGAZINE

Health & Medicine | Mind & Brain | Technology | Space | Human Origins | Living World | Environm

HUGE sunspots turning toward Earth

As the Sun rotates roughly once per month, we see different features come into view... and the latest is an *enormous* sunspot system which just came around the limb of the Sun:

SCIENTIFIC AMERICAN

Third Van Allen Belt Came and Went

The Van Allen Probes recently found a third ... Earth, which was then destroyed by a solar ...

CBSNEWS

Voyager 1 finally crosses into interstellar space

USA TODAY

A GANNETT COMPANY

NEWS SPORTS LIFE MONEY TECH TRAVEL OPINION 26° GAMES

Sun's magnetic field flips

science FRIDAY

SPACE

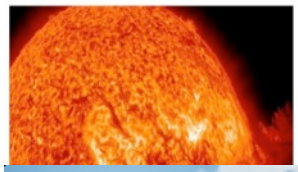
The Solar Wind is an Interplanetary Water Factory

JAN 21, 2014 03:00 PM ET // BY IRENE KLOTZ

LIFE Magazine

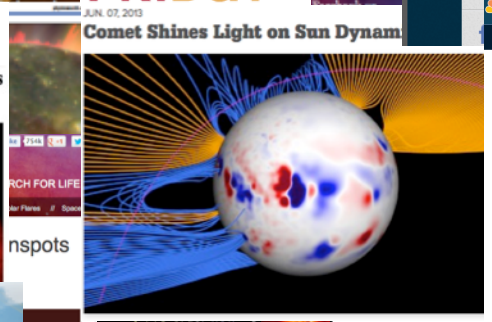
The Washington Post NATIONAL

As the sun awakens, the power grid stands vulnerable



JUN. 07, 2013

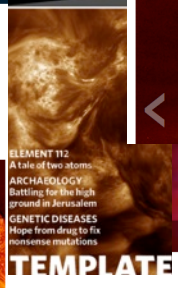
Comet Shines Light on Sun Dynam...

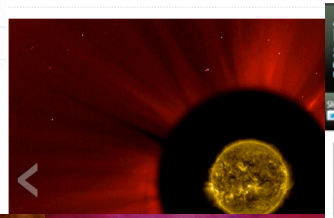


NBC NEWS HOME LATEST SEARCH

Comet ISON finally pronounced dead after close encounter with sun

BY SETH BORENSTEIN

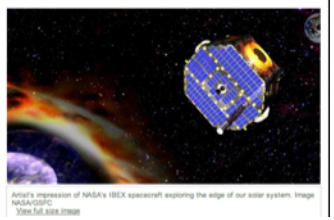




SPACE.COM

TRENDING: Comet ISON // Skywatching G...

Article:
NASA to Reveal New Details About Solar System's Edge



WTOP 103.5 FM

There's weather in space as well as our skies

Recommend 2 +1 2

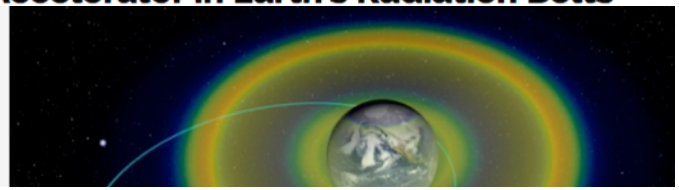
Monday - 2/24/2014, 12:52am ET

By Greg Redfern
More Reports

WASHINGTON -- With our terrestrial weather (winter) having been such a factor in our daily lives recently here in

SCIENCE WORLD REPORT sciencewr.com

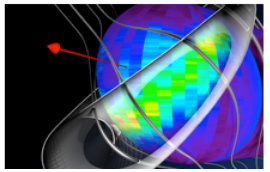
NASA Van Allen Probes Discover Particle Accelerator in Earth's Radiation Belts



Mysterious Energy Ribbon at Solar System's Edge a 'Cosmic Roadmap'

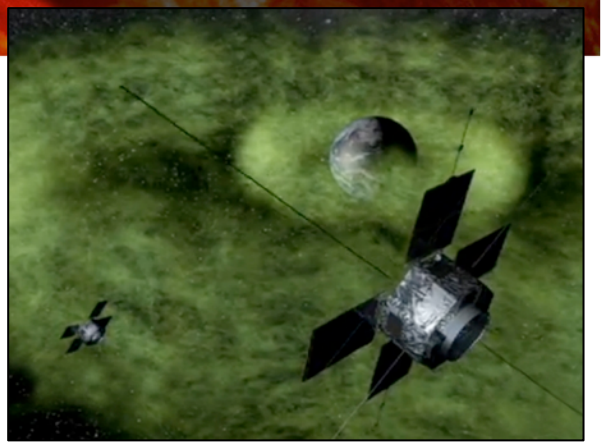
By Elizabeth Howell, Space.com Contributor | February 13, 2014 02:01pm ET

1004 Share 415 Tweet

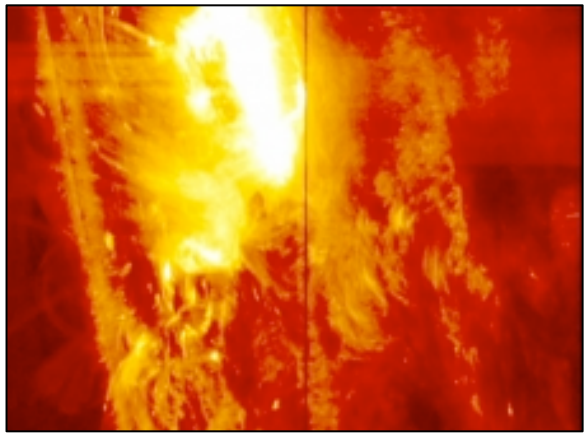


A strange ribbon of energy and particles at the edge of the solar system first spotted by a NASA spacecraft appears to serve as a sort of "roadmap in the sky" for the interstellar magnetic field, scientists say.

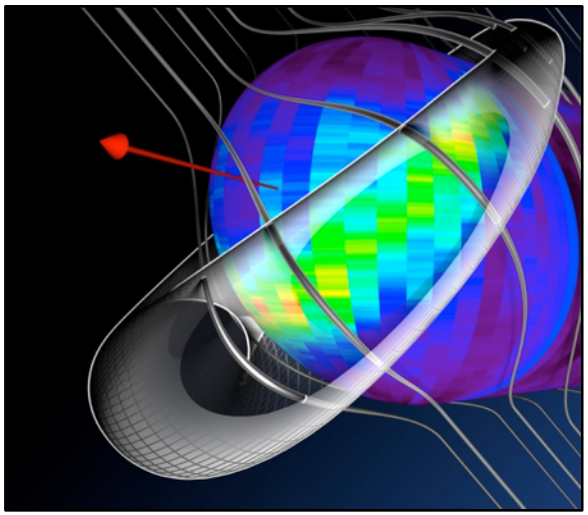
Recent Major Accomplishments – Science



20 December 2013 – Van Allen Probes Reveal Origin of Ultra-relativistic Electrons in Near-Earth Space: Van Allen Probes data, during a geomagnetic storm on Oct. 9, 2012, along with a data-driven global wave model reveal that linear, stochastic scattering by intense, natural very low-frequency radio waves -- known as chorus waves -- can account for the build-up of relativistic electrons in Earth's upper atmosphere.



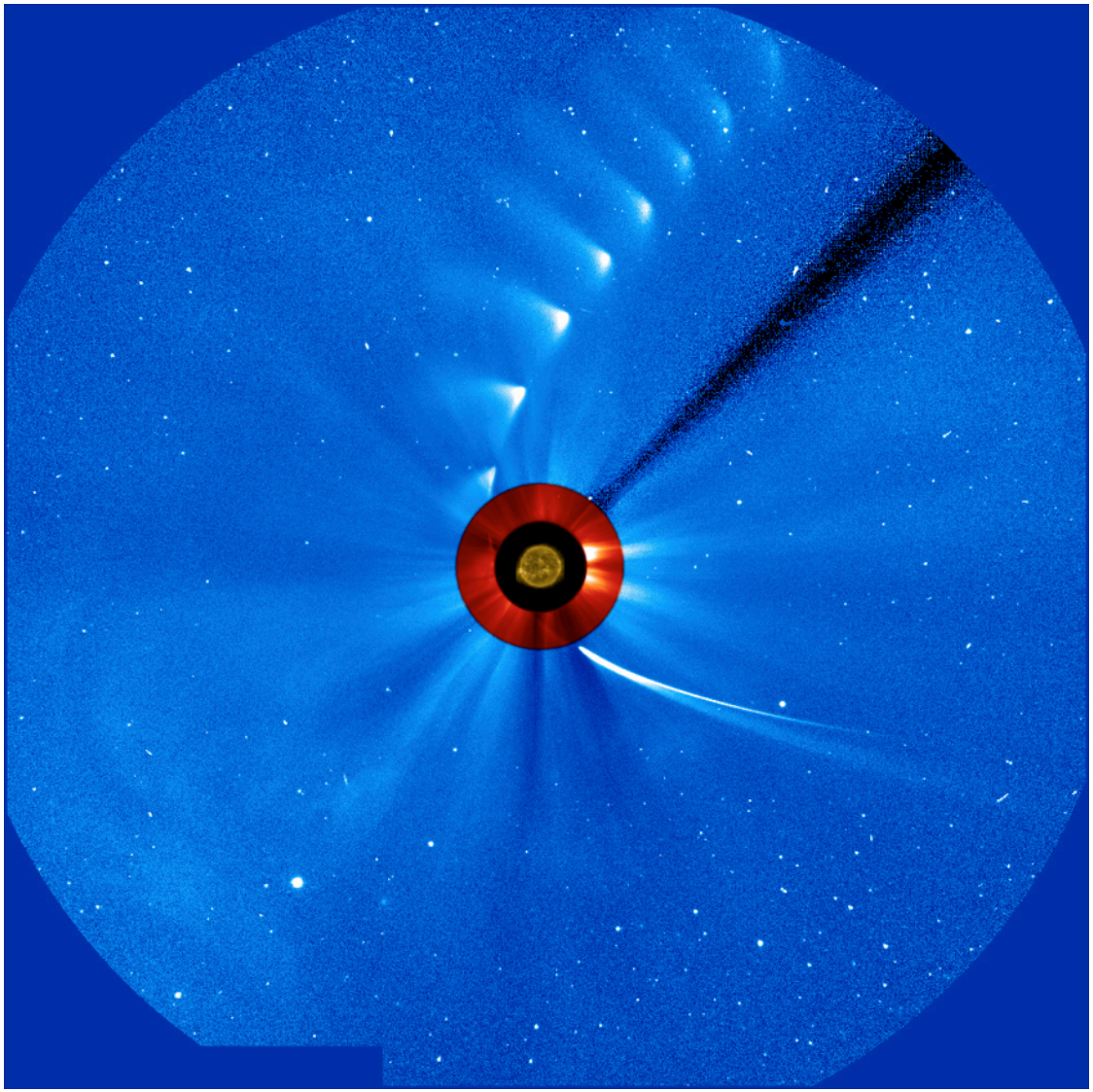
28 January 2014: IRIS Observes Its Strongest Flare Since Launch: IRIS is the first mission designed to simultaneously observe the range of temperatures specific to the chromosphere, which is key to regulating the flow of energy and material as they travel from the sun's surface out into space.



13 February 2014 – IBEX Sheds Light on Physics Outside the Heliosphere: IBEX data sets show a magnetic field that is nearly perpendicular to the motion of our solar system through the galaxy. In addition to shedding light on our cosmic neighborhood, the results offer an explanation for the mystery of why we measure more incoming high-energy cosmic rays on one side of the sun than on the other.

Heliophysics Instruments Observe Comet ISON

Significant changes observed post-perihelion: “comet cookery”



"Time lapse" series of images of comet ISON as viewed by ESA/NASA's Solar and Heliospheric Observatory, or SOHO.

This image is a composite, from the LASCO C2 and C3 coronagraphs, with the sun imaged by NASA's Solar Dynamics Observatory shown in the center.

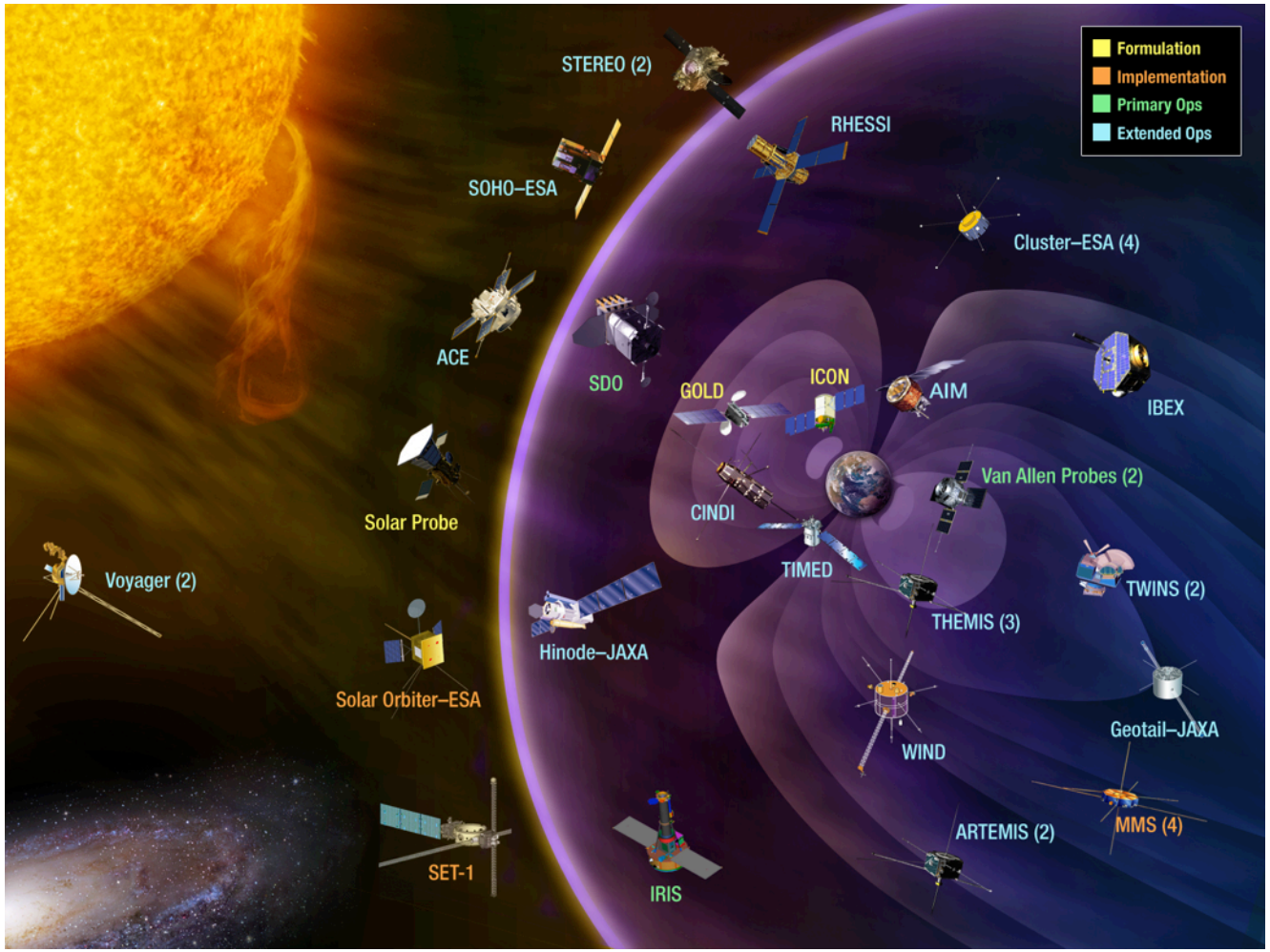
The first image (showing the comet below the Sun) was taken 14:30 UT on 28 November, the first of the three post-perihelion images was taken 9 hours later, at 23:30 UT. The other post-perihelion images, taken over November 29 and 30, show the comet disappearing.

Program Accomplishments

- **BARREL** balloon campaign in Antarctica successfully completed
- **ICON** & **GOLD** successfully completed System Requirements Reviews
- **MMS** 3 of 4 vehicles successfully through thermal vac, 4th after stacked vibration
- **Solar Probe Plus** successful PDR, successful Mission Confirmation (KDP-C)

Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system



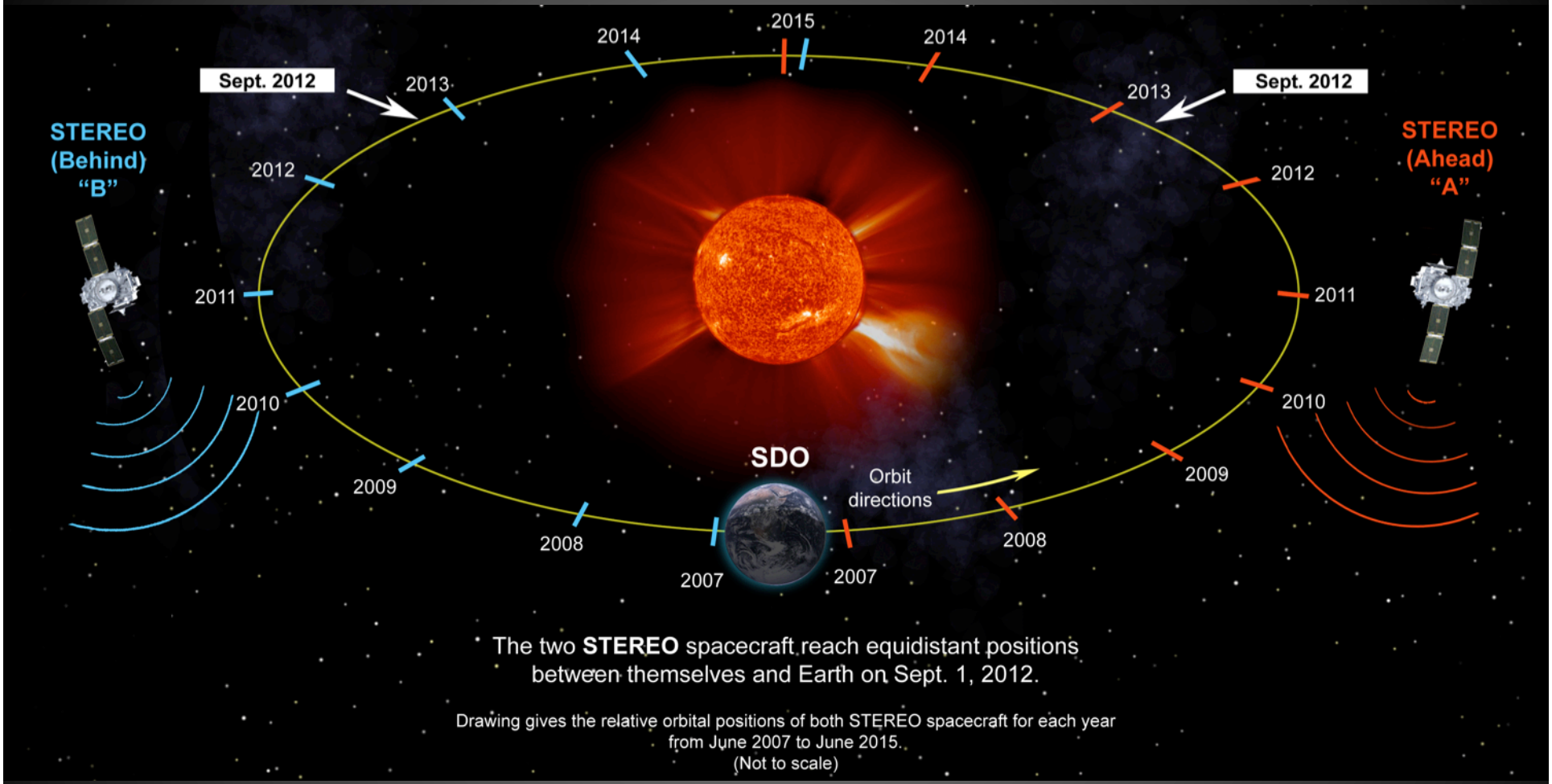
- **Heliophysics has 18 operating missions (on 29 spacecraft):** **Voyager, Geotail, Wind, SOHO, ACE, Cluster, TIMED, RHESSI, TWINS, Hinode, STEREO, THEMIS/ARTEMIS, AIM, CINDI, IBEX, SDO, Van Allen Probes, IRIS**

  (Missions in red contribute to operational Space Weather.)

- **6 missions are in development:** **SET, MMS, SOC, SPP, ICON, and GOLD**

$5.5B total investment in Heliophysics space assets (excluding launch costs)
$68M annual operating budget (1.2% per year)

STEREO is still going strong after >7 years



Launched 26 October 2006.

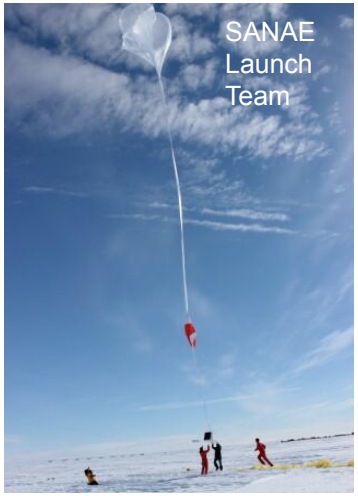
STEREO-B instruments have recovered from the 20 February anomaly!

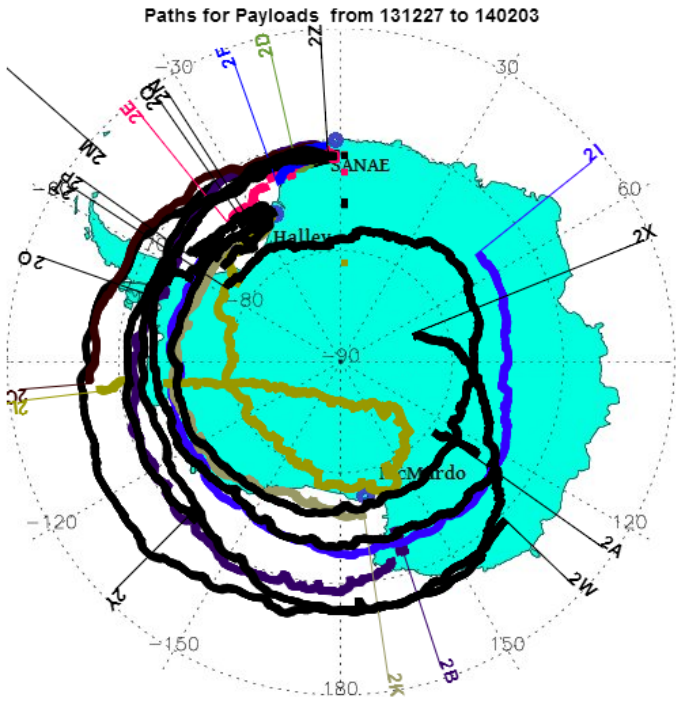
2014 BARREL Flights

2014 Campaign Successfully Completed

Balloon Array for RBSP Relativistic Electron Losses (*BARREL)* *

- Campaign #2 (window Dec 23 – Feb 1) completed, fully successful
- 17 Balloons were successfully launched; Dec 27- Feb 3; last remaining payload in flight cut down Feb 11





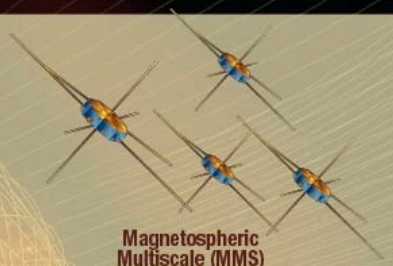
http://www.youtube.com/watch?v=KWmDNcKw70I

http://relativisticballoons.blogspot.com/

*Logistical support for the BARREL project in Antarctica was provided by the US National Science Foundation through the US Antarctic Program

Heliophysics Program 2013-2018

Solar Terrestrial Probes

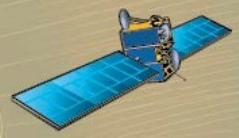


Magnetospheric Multiscale (MMS)
March 2015

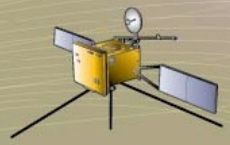
STP #5

Living With a Star

Van Allen Probes
August 2012



Space Environment Testbeds (SET)
Mid-2015



Solar Orbiter Collaboration (with ESA)
July 2017

Solar Probe Plus
July 2018

Explorers

Interface Region Imaging Spectrograph (IRIS)
June 2013

Ionospheric Connection Explorer (ICON)
2017

Global-scale Observations of the Limb and Disk (GOLD)
2017

Research Program

VESPR - November 2013
Comet ISON - November 2013
GREECE - January 2014
RAISE - February 2014

VAULT - April 2014
HYPE - April 2014
SubTec Demo - April 2014
CHESS - May 2014

MOSES - June 2014
DFS - July 2014
RockOn Vii- June 2014
Micro-X - June 2014

OGRE - August 2014
RockSatX- August 2014
PEREGRINE#1 - September 2014
PEREGRINE#2 - October 2014

PICTURE - October 2014
CAPER - December 2014

Ongoing

BARREL #2 - January 2014/Antarctica

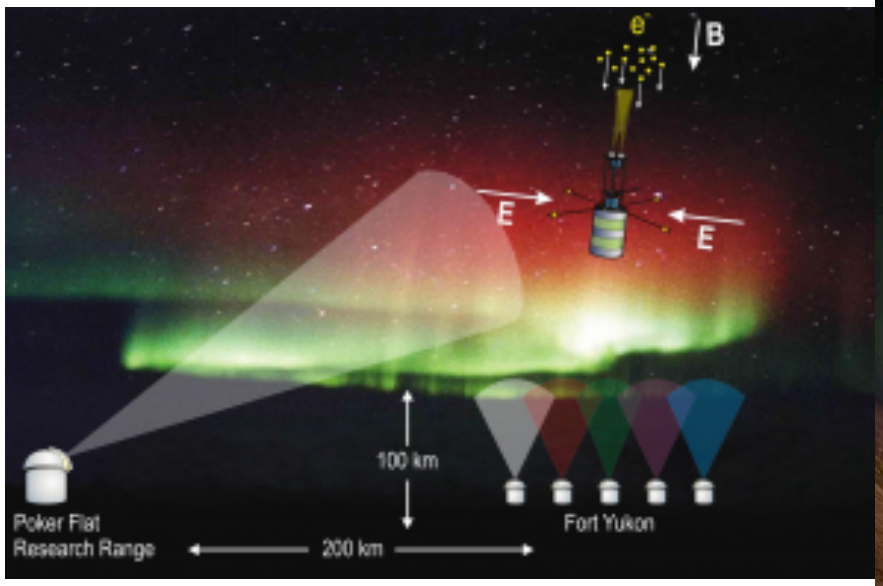
Heliophysics Missions
Astrophysics Missions
Planetary Missions

2012 2013 2014 2015 2016 2017 2018

Significant Progress: Rockets

Launch Operations: Poker Flat

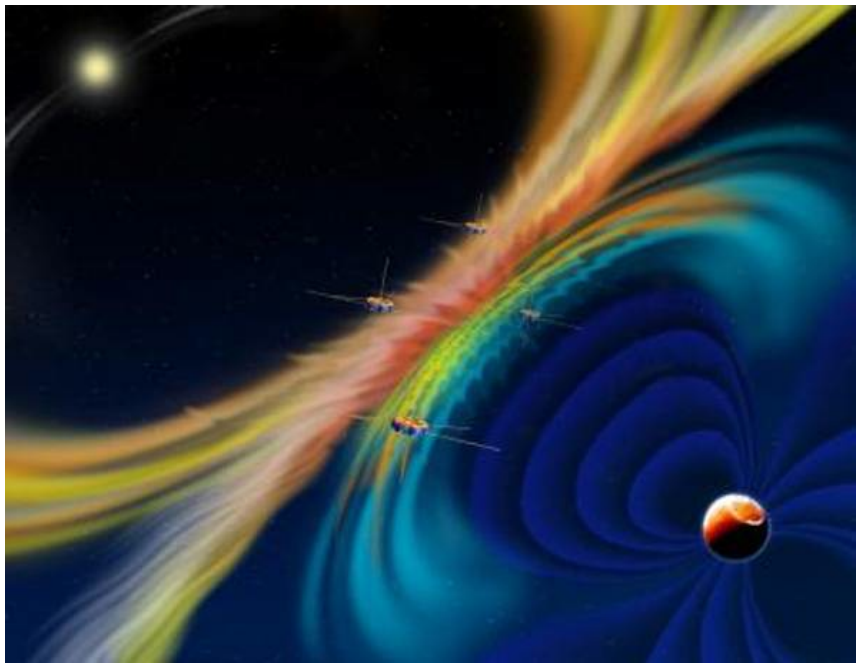
- **Ground-to-*rocket* Electrodynamics-. Electrons Correlative Experiment (*GREECE*) mission, PI: Marilia Samara/SWRI**
- Objective: to study the electromagnetic processes behind dynamic auroral displays
  - Looking for a bright dynamic substorm onset aurora or a stable arc with fluid like motions over the village of Venetie (Apogee point & location of ground based optics)
- Successful Flight March 3, 2014



Schematic diagram showing an initial concept of the GREECE rocket payload overflying dynamic auroral displays. The payload is measuring the electromagnetic field and energetic electrons associated with the auroral displays, while high-speed, narrow-field imagers on the ground provide images of the aurora itself (image courtesy M. Samara and R. Michell, SwRI).

Wallops Research Range FY14 Operations

Magnetospheric Multi-Scale (MMS)



Science Objective: Investigate the physics of magnetic reconnection, using a constellation of 4 satellites to probe the reconnection region

Partners

- IWF (Austria), LPP (France), ISAS (Japan), KTH (Sweden)
- KSC Launch Services Program for Atlas V

Instruments

- Instrument Suite: SwRI
  - Fields suite (6 sensor types): UNH, U Colorado, UCLA, IWF, LPP
  - Fast Plasma Investigation (2 sensor types): GSFC, Meisei, SwRI
  - Energetic Particles (2 sensor types): APL, Aerospace
  - Hot Plasma Composition: SwRI
  - ASPOC: IWF

Overall Status

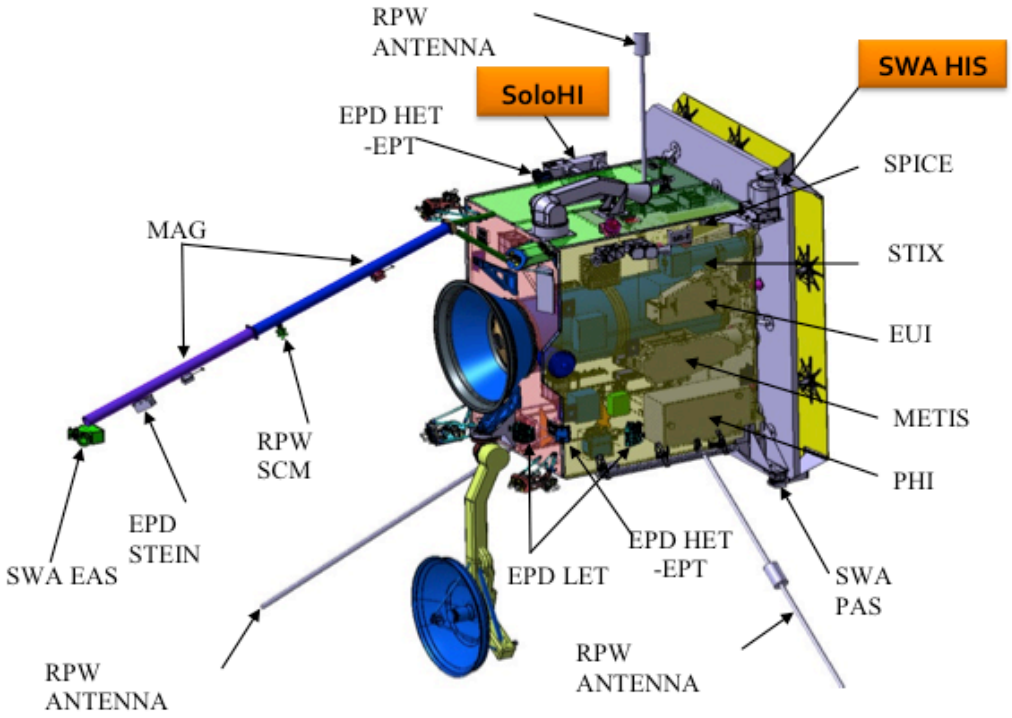
- All 4 satellites are in system-level test
- 2 of 4 completed thermal vacuum test
- Quality issues on one electronic part (HV801)
  - Several instruments affected
  - Additional testing planned
- Significant cost, schedule impacts of shutdown
- Launch readiness changed from 14 October to 26 November 2014 to recover schedule margin
- Launch date commitment expected soon

MMS Observatory Status

- Observatory #2 in post-TVAC work. TVAC successfully completed on 23 December 2013
  - FPI heater circuit revision implemented (keeps HV801s warmer)
  - Propulsion thermostat problem troubleshooting completed (inconclusive)
- Observatory #1 TVAC test completed on 13 February 2014
  - Overall very successful, but one APSOC instrument failed and Navigator (side A only) experienced a gain loss. Both problems are being investigated
  - Apparent malfunction of two propulsion thermostats also being investigated
- Observatory #4 completed TVAC March 2014.
- Observatory #3 now has all instruments integrated, final harness & blanket installation
  - Thermal vacuum test will be done after stacked vibration test
- All 4 observatories combine for a stacked vibration test, planned for 7 April 2014
- FPI Super Suite Test #2 in progress, one HV801 failure at ~220 hours (1500 hour test)
- Working to 26 November 2014 launch readiness date
- Resolution of furlough-induced launch date issue expected in the next few weeks
  - Launch date commitment will help quantify cost impact of government shutdown

Solar Orbiter Collaboration (SOC)

Solar Orbiter was selected as the first medium-class mission of ESA's Cosmic Vision 2015-2025 Program

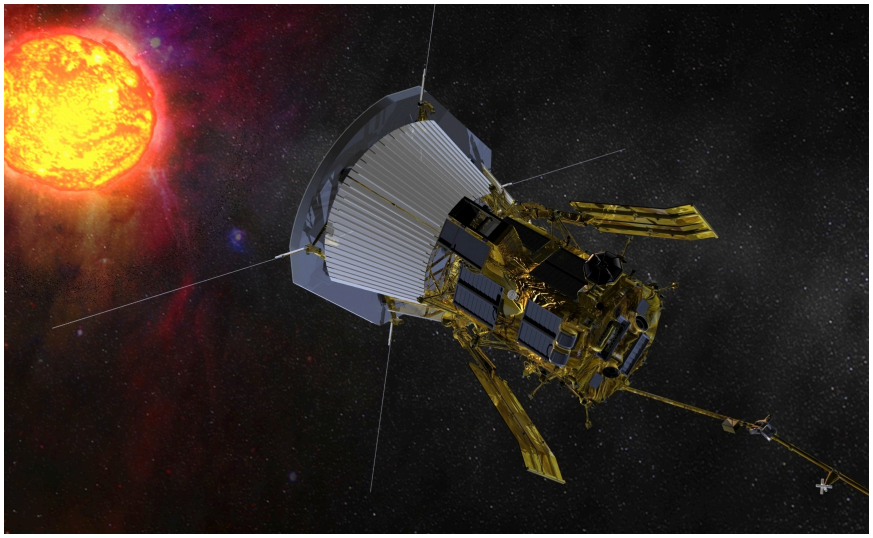


➢ **Mission design:**

- Launch: July 2017 (2018 backup)
- Multiple gravity assist maneuvers (Venus, Earth)
- Minimum perihelion: 0.28 AU
- Out of the ecliptic angle: 25°
- Maximum solar latitude: 35°
- Total mission duration: 7 years (plus 3 years of extended phase)
- LV – Atlas V 411 (just announced)

US-funded instruments SoloHI (NRL) and HIS (SwRI) are preparing for 2015 deliveries to support a July 2017 launch.

Solar Probe Plus (SPP) and KDP-C



Overview

Using in-situ measurements made closer to the Sun than by any previous spacecraft, SPP will determine the mechanisms that produce the fast and slow solar winds, coronal heating, and the transport of energetic particles.

Solar Probe Plus will fly to less than 10 solar radii (R_s) of the Sun, walking-in from 35 R_s over 24 orbits.

- Sponsor: NASA/GSFC Living With a Star (LWS)
- LWS Program Manager – Nick Chrissotimos GSFC
- LWS Deputy Program Manager – Mark Goans, GSFC
- Project Manager – Andy Driesman, APL
- Project Scientist – Nicky Fox, APL
- Spacecraft Development & Operations – APL
- Investigations selected by AO:
  - FIELDS – University of California
  - ISIS – Southwest Research Institute
  - SWEAP – Smithsonian Astrophysical Obs
  - WISPR – Naval Research Laboratory
  - HelioOrigins – Jet Propulsion Laboratory

Milestones

	Pre-Phase A:	07/2008 – 11/2009
✓	Phase A:	12/2009 – 01/2012
✓	Phase B:	02/2012 – 03/2014
	Phase C/D:	03/2014 – 08/2018
	LRD:	31 July 2018
	Phase E:	09/2018 – 09/2025

Formulation Range: $1233M - $1439M

KDP-C ~$1.5B

Successful PDR just completed, Confirmation (KDP-C) just approved

Stable Requirements Through Phase B

- There have been no changes to science measurements requirements since MDR.
- Perihelion requirement was raised from 9.5 Rs to <10 Rs.
  - No impact on science.
  - Lowered C3 requirement from 159 km^2/s^2 to 154 km^2/s^2. Increased available lift mass by 55 Kg.
  - Rise in perihelion caused slight reduction in the number of hours required below 10 Rs and 20 Rs.

	MDR L1 Requirements		PDR L1 Requirement	
	Hours <20Rs	Hours <10Rs	Hours <20Rs	Hours <10Rs
Baseline	950	25	920	14
Threshold	500	9	400	8

- No Changes to Mission Success Criteria
- All other changes were for clarity.

SPP Launch and Mission Overview

Launch

- Dates: Jul 31 – Aug 19, 2018 (20 days)
- Max. Launch C3: 154 km^2/s^2
- Requires Atlas V 551/Delta IVH class with project-provided Upper Stage

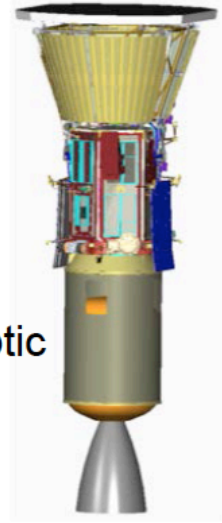
Trajectory Design

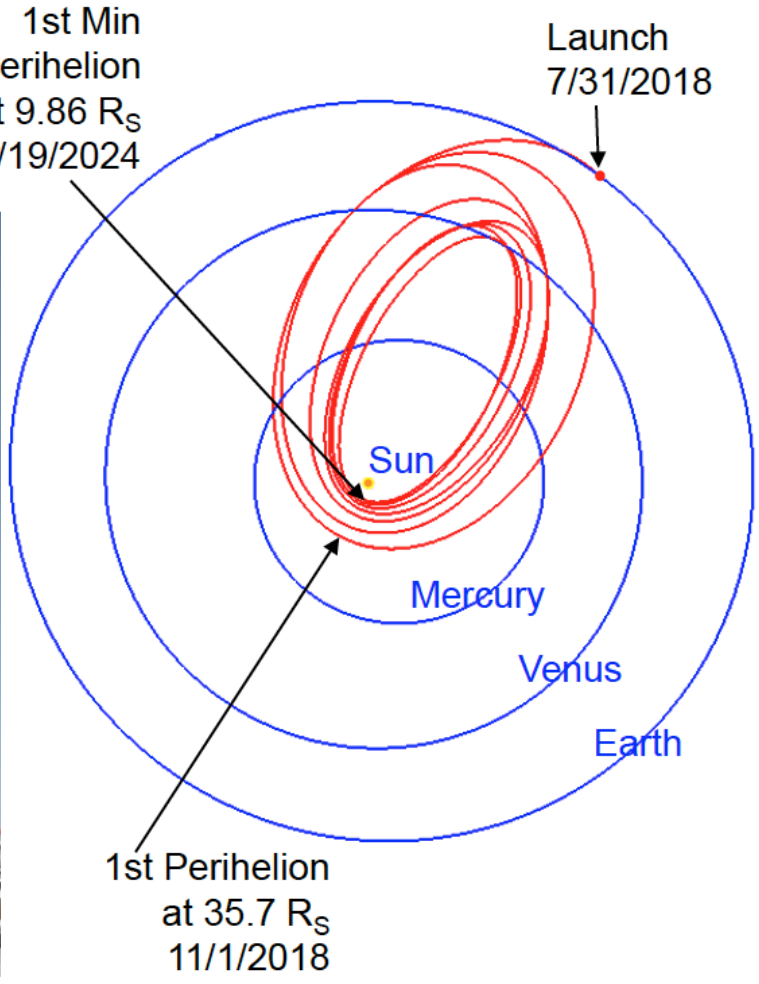
- 24 Orbits
- 7 Venus gravity assist flybys

Final Solar Orbits

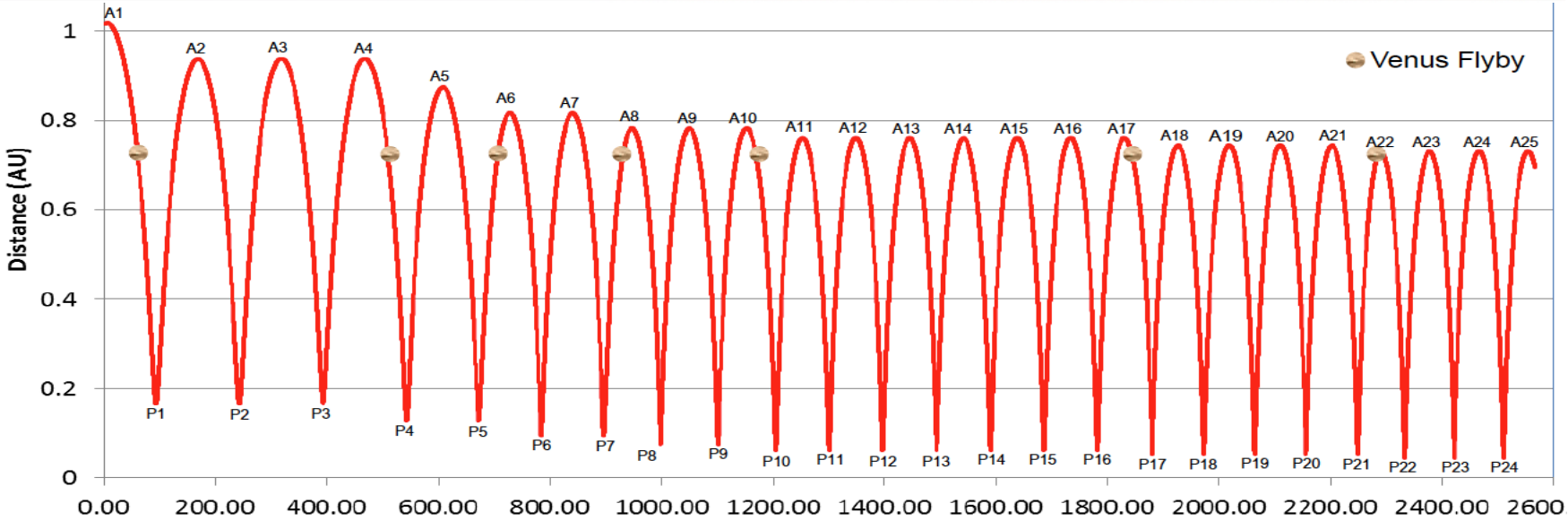
- Perihelion: 9.86 R_S
- Aphelion: 0.73 AU
- Inclination: 3.4 deg from ecliptic
- Orbit period: 88 days

Mission duration: 7 years





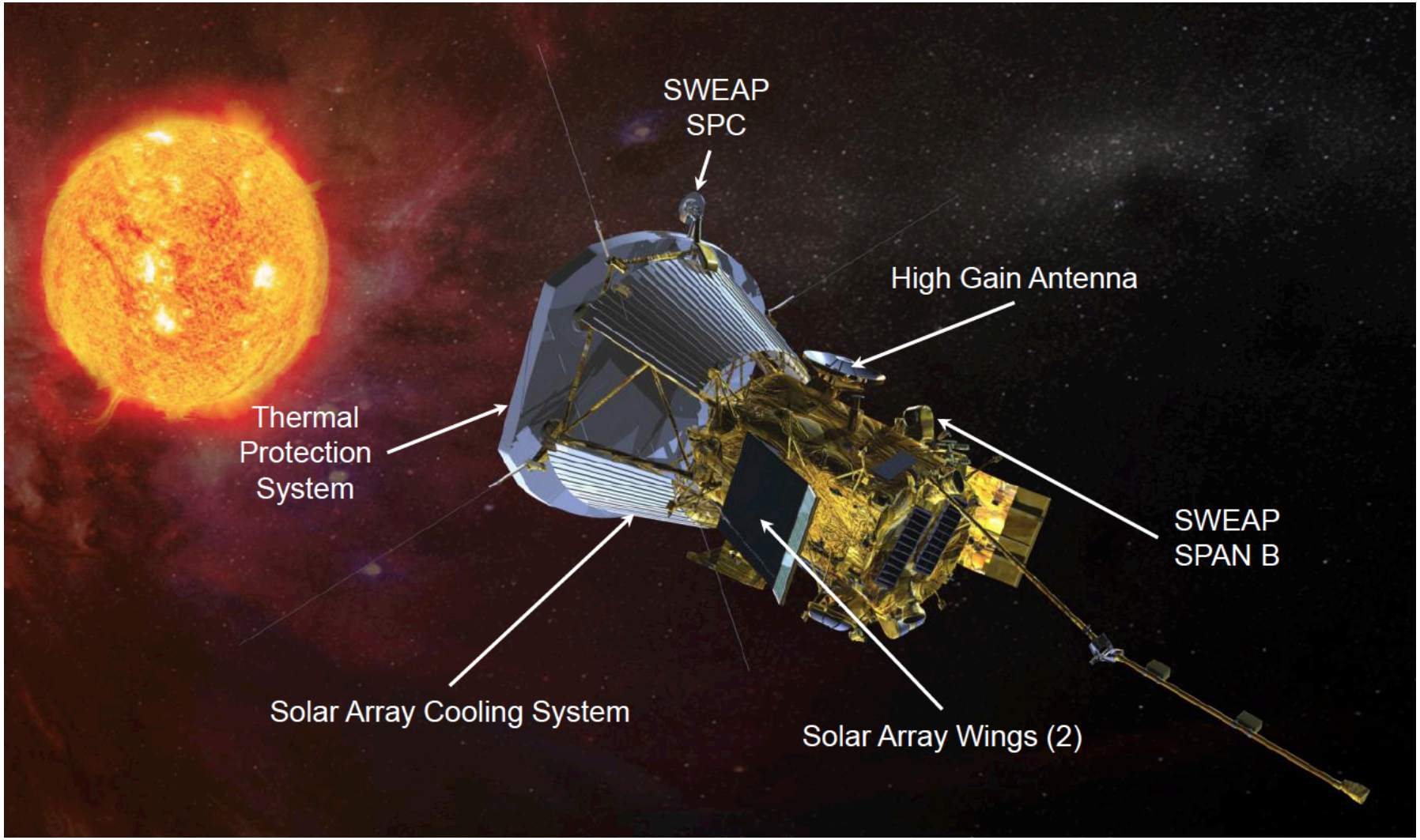
Perihelion Lowered Using Venus Flybys



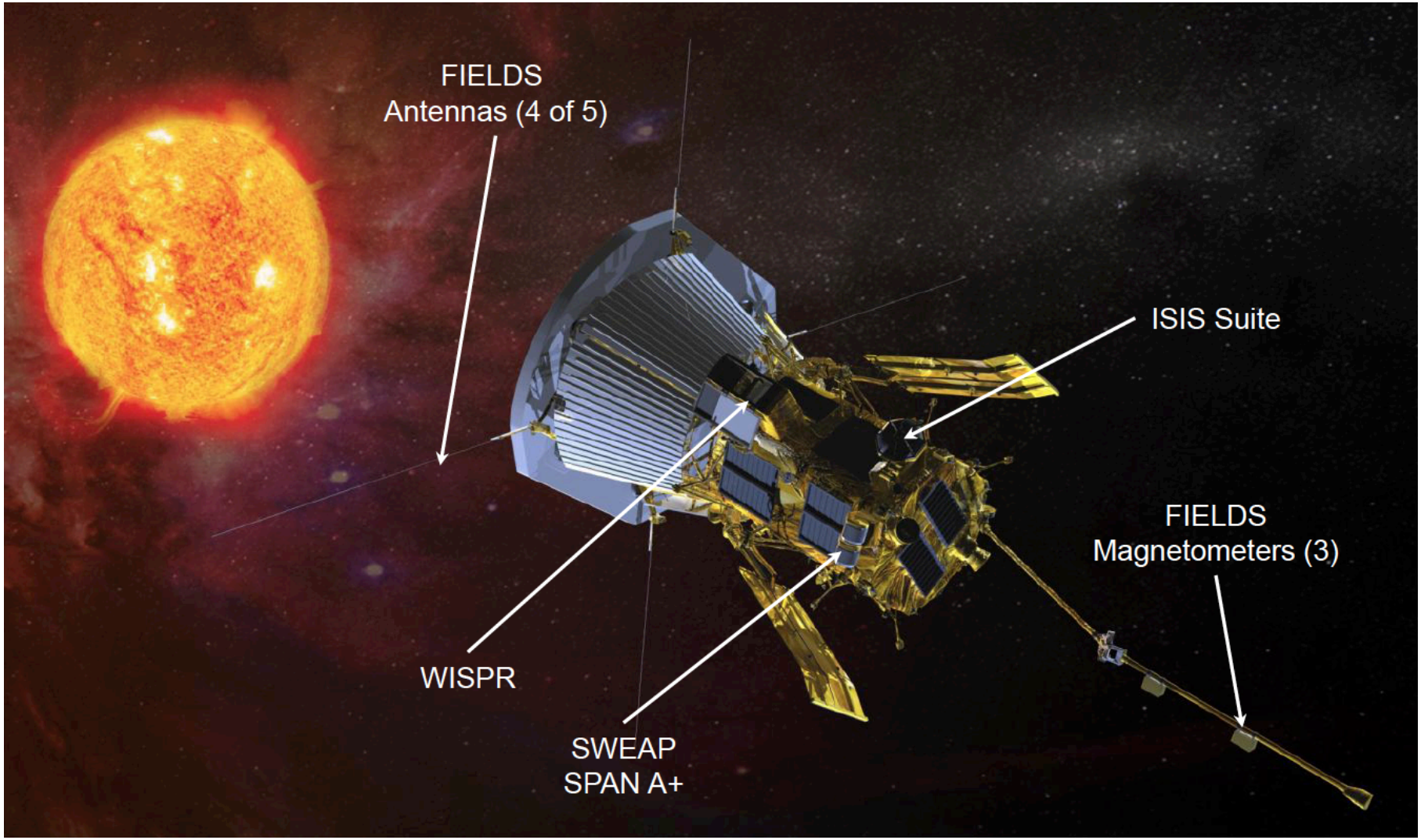
Solar Pass #	Perihelion (AU)	Perihelion (Rs)	Time within 30 Rs (hr)	Time within 20 Rs (hr)	Time within 15 Rs (hr)	Time within 10 Rs (hr)
1	0.163	35.66				
2	0.163	35.66				
3	0.163	35.66				
4	0.128	27.85	61.04			
5	0.128	27.85	61.05			
6	0.092	20.35	104.22			
7	0.092	20.35	104.22			
8	0.072	15.98	108.55	48.06		
9	0.072	15.98	108.55	48.06		
10	0.06	13.28	107.27	55.13	24.75	
11	0.06	13.28	107.27	55.13	24.75	
12	0.06	13.28	107.27	55.12	24.75	
13	0.06	13.28	107.27	55.13	24.75	
14	0.06	13.28	107.27	55.12	24.74	
15	0.06	13.28	107.27	55.12	24.74	
16	0.06	13.28	107.27	55.12	24.73	
17	0.052	11.42	105.03	56.91	32.23	
18	0.052	11.42	105.03	56.91	32.23	
19	0.052	11.42	105.03	56.91	32.23	
20	0.052	11.42	105.03	56.91	32.23	
21	0.052	11.42	105.03	56.91	32.23	
22	0.044	9.86	102.40	57.02	35.22	4.94
23	0.044	9.86	102.40	57.02	35.22	4.95
24	0.044	9.86	102.40	57.02	35.22	4.95
Total			2130.85	937.58	440.03	14.85
Requirements:				920		14

- 24 perihelion passes in 7 years
- 7 Venus flybys yield 7 groups of passes, 2 to 7 perihelia per group
  - Repeated passes cover a broad range of solar longitudes
- Key science metrics are total times below 20 R_s and 10 R_s

Observatory Configuration (1 of 2)



Observatory Configuration (2 of 2)



Solar Probe Plus Review Triggers

- Solar Probe Plus completed a very successful PDR in January 2014
  - The #1 program risk at PDR was concern over funding shortfall for 2018 launch
- Life cycle cost (LCC) estimate for SPP is ~$1.5B
  - Significantly greater than the $1.23B trigger level of the 2013 Decadal Survey
- Key Decision Point C established the NASA baseline
- This is the official life-cycle cost for a July 2018 launch
- At KDP-C the SPP LCC will exceed the Decadal Survey's "Trigger 3"
- NASA/HPD discussed with NRC Committee Solar And Space Physics (CSSP), established that KDP-C process is the appropriate project review.

SPP Cost History Since 2009

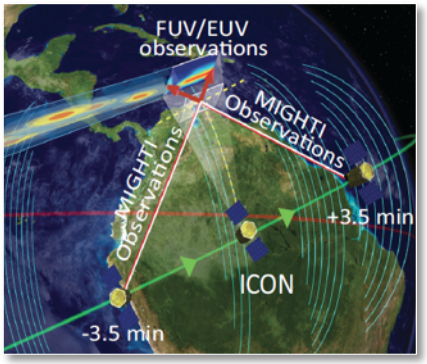
- KDP-C life cycle cost (LCC) estimate for SPP is now ~$1.5B. Based on:
  - Solid, successful PDR, completed with review board kudos and approval to proceed
  - Detailed APL and instrument proposals for (almost) all implementation phase activities
  - Confirmed by multiple independent assessments and parametric estimates
  - Includes 28% reserves held by APL, plus significant additional HQ reserves
- November 2009: SMD Management Council approved $1.233B LCC
  - This was the source of the cost estimate provided to the Decadal Survey committee
- January 2012: Approved KDP-B estimated LCC was $1.233B to $1.439B
  - Upper end included reserves for LV, upper stage development, 2.6% (modest) UFE
- Increase in estimated cost since KDP-B is ~$100M ($1.439B to ~$1.5B)
- Cost increases since KDP-B are driven by more realism, conservatism:
  - $125M more in launch vehicle cost (even more than budgeted in previous upper limit)
  - Significant additional UFE to protect other missions against cost growth by SPP
  - No enhancements in any aspect of mission performance

Two New Explorers for Heliophysics

Selected in 2013 for Flight Development, Launch in 2017

ICON

Ionospheric Connection Explorer



- **How neutral atmosphere affects the ionosphere**
- **How solar wind and magnetosphere affect the ionosphere**

ICON is a single s/c traveling eastward and continuously imaging the thermosphere and ionosphere.

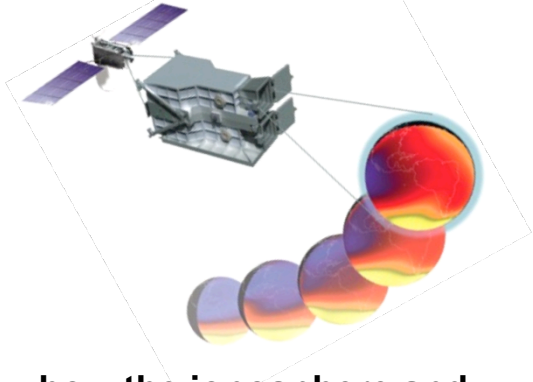
Orbit: 550 km at 24^{o} inclination

PI: **Thomas Immel** / UC Berkeley

- Successful SRR in January 2014
- PDR in June 2014
- Confirmation Review in July 2014

GOLD

Global Scale Observations of the Limb and Disk



… how the ionosphere and thermosphere respond to geomagnetic storms, solar radiation, and upward propagating atmospheric tides

Two identical scanning imaging spectrographs on a geosynchronous commercial communication satellite.

PI: **Richard Eastes** / U. Cent. FL

- Successful SRR in January 2014
- PDR in September 2014
- Confirmation Review in Oct 2014

Research

Helps ensure the vigor, vitality, and high quality of HPD research.

- The **Research Program** is <u>essential</u> to the scientific productivity of HPD
  - Operations and data analysis for extended missions
  - Annual research proposal opportunities open to the entire scientific community
  - The “mortar” that binds individual missions to form the Heliophysics System Observatory
- Leverages NASA’s investment in the HSO for large impact at low cost
  - Enables and funds heliophysics theory and modeling (deeper understanding)
  - Enables contributions from outside of core mission teams (community breadth)
  - Enables cross-mission, correlative, and “system” research (technical breadth)
  - Funds technology development, data sharing (development and infrastructure)
  - Funds Low-Cost Access to Space and rocket program infrastructure (diversify)
- Supports applications of heliophysics science to space weather prediction
  - Community Coordinated Modeling Center (CCMC)
  - Space Weather Research Center (SWRC)
  - Model testing, verification, and validation for transition to operations at NOAA/SWPC

We are committed to increasing the Research fraction of the budget per the recommendations of the 2013 Decadal Survey.

ROSES 2014 Released on 18 Feb

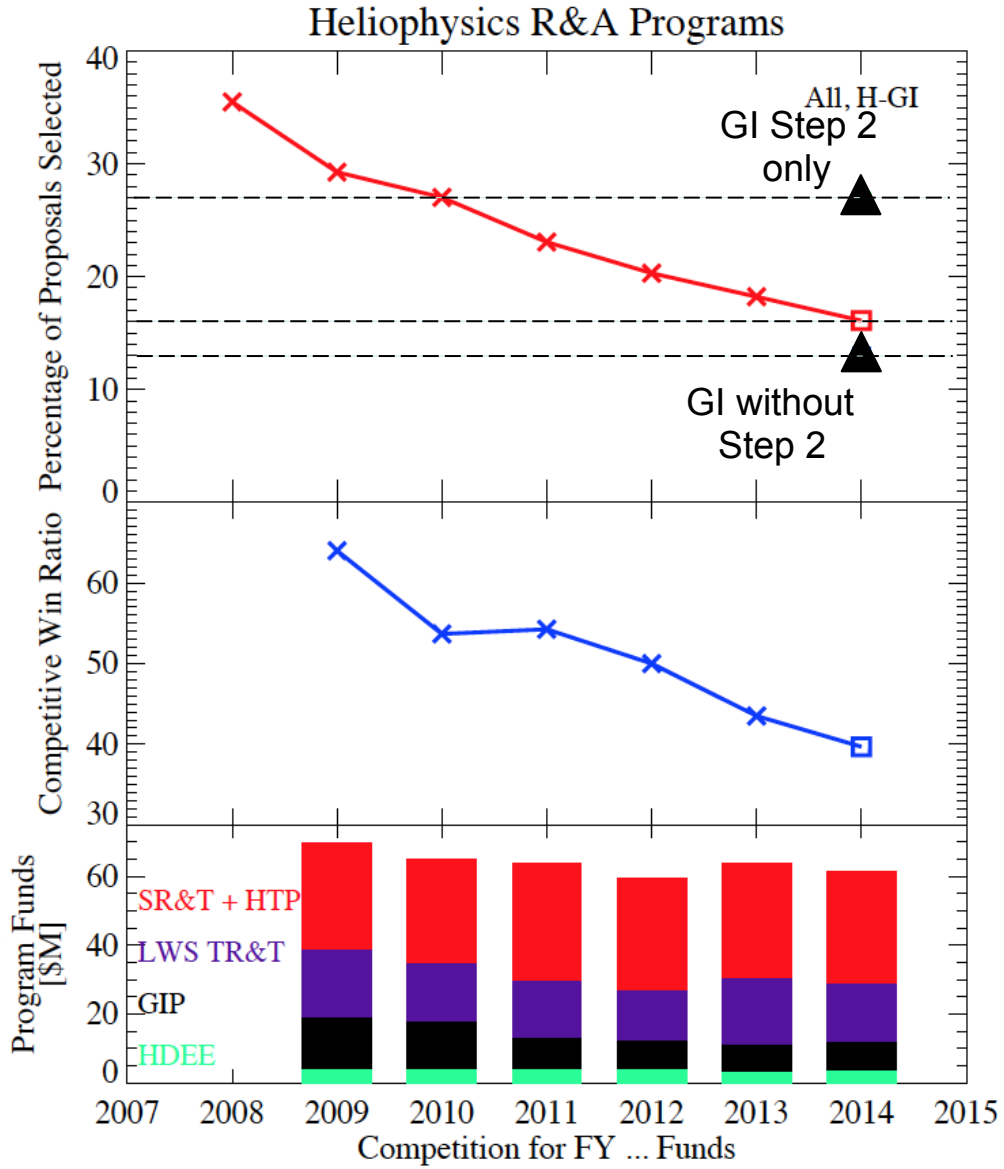
- **Heliophysics ROSES Solicitations Will Continue Utilizing the Two-Step Process**
  - Encourage/Discourage Test Was Successful in ROSES13 H-GI, expand to H-SR in 2014
  - **H-GI, H-SR: Encourage/Discourage in Step 1**. Three-Page Step-1 Proposals Required
  - **H-LWS, H-TIDeS and H-IDEE Step-1**: Single-Page, Team Fixed, **Compliance Check Only**
- **Duplicate Proposals Risk Rejection due to Noncompliance**

ROSES 2014 Program Elements

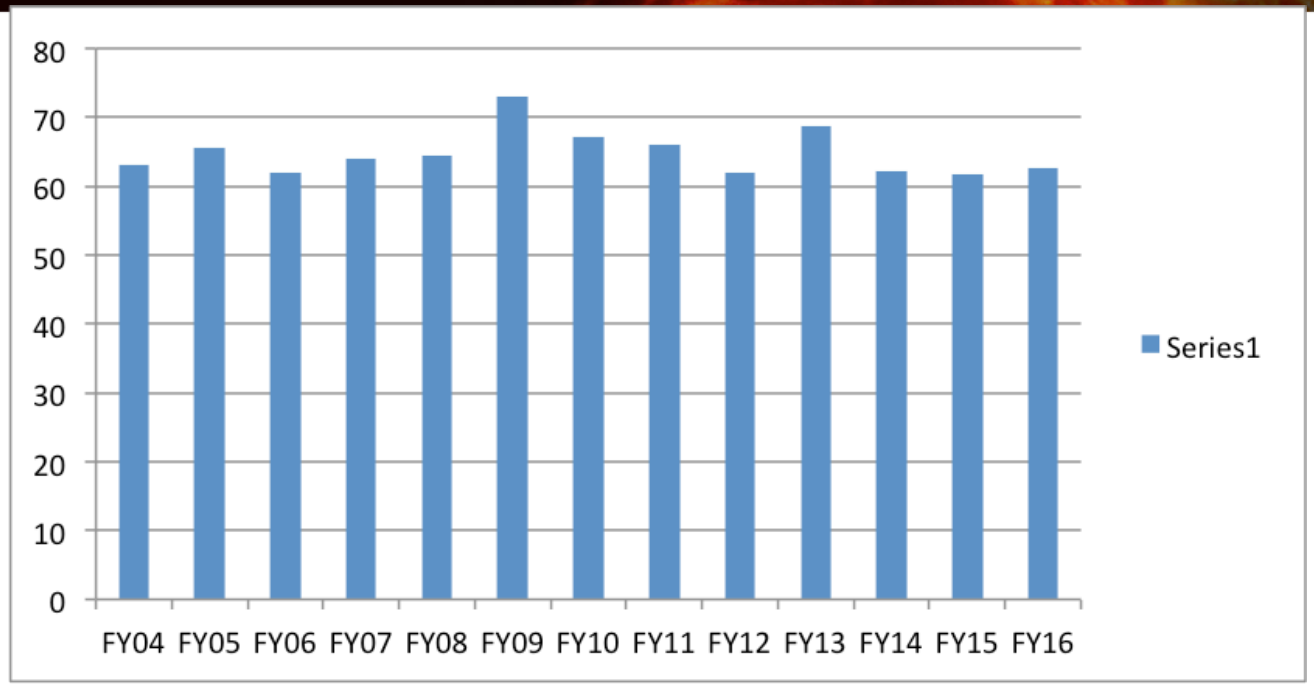
- **Guest Investigator (H-GI)**
  - IRIS and Van Allen/BARREL Opportunities
  - Open Data Development Element: Open to all HSO Missions, Focus on data set development
- **Supporting Research (H-SR)**
  - Highest priority will be proposals that use data from current or historical NASA spacecraft together with theory and/or numerical simulation to address one of the four Heliophysics Decadal Survey goals
- **Living With a Star (H-LWS)**
  - No Workshops, no Strategic Capabilities
  - Focus Topics being developed
  - Details on NSPIRES
- **Technology and Instrument Development for Science (H-TIDeS)**
  - Low Cost Access to Space
  - Instrument and Technology Development
  - Laboratory Nuclear, Atomic, and Plasma Physics
- **Grand Challenge Research (H-GCR)**
  - Currently Fully Subscribed. Not Competed in ROSES14.
- **Infrastructure and Data Environment Enhancements (H-IDEE)**
  - Only Infrastructure.
  - Heliophysics Data Services CAN Solicited Outside ROSES

Issues and Concerns: Research Support

- Community demand for research support is far from satisfied
  - Number of proposals is rising
  - Fraction funded is falling to 1 in 6
- What are we doing?
  - "Rebalancing" to increase research fraction of total budget
  - Expanding the 2-step process
- What can you do?
  - Don't clog the system with multiple, similar proposals
  - Focus on the highest priority science investigations
  - Help your colleagues with focused criticism to help them propose only the most compelling science



Competed Research Funding



This is the Sum(SR&T+GI+TR&T+Data/Modeling+Theory). These are all roughly constant (33+8+17+3), the GI having the largest swings over this time period. There are some borrow/paybacks (e.g. LWS in FY12/13) that add some of the noise.

Consequence of flat (RY$) funding – Next page

NASA's New CubeSat Program

- Heliophysics is administering SMD's new CubeSat budget, $5M/yr in FY14
- Management approach approved at SMD level on 20 February
  - HQ-based administration, "thin" program office supported part-time
  - Modest contribution to support KSC CubeSat Launch Initiative for accommodations
  - CubeSat proposals will be solicited via ROSES and selected by each SMD Division
  - Science CubeSat Integration Panel established
- Science CubeSat Integration Panel responsibilities:
  - Establish policy, incorporate lessons learned, and conduct outreach
  - Integrate management and implementation as needed
  - Recommend awards following review by Divisions
- CubeSat proposals received and reviewed to be considered for 2014 awards

NASA CubeSat proposals will be solicited and selected on the basis of science merit and technology value.

Topics for discussion

- **NASA's Heliophysics Division Objectives and Organization**
- **Recent Accomplishments, Program Updates, Current Status**
- **Heliophysics Budget Allocations and Projections**
- **Future Planning and Status of Decadal Survey Implementation**
- **Upcoming Key Events, Issues, Discussion**

Key Budget Consequences for Heliophysics

The Heliophysics budget for FY15 is increased over FY14

- Net of administrative items: $609.8 in FY14, to $613.9 in FY15

The budget sustains long-standing HPD programs

- Research & Analysis, operating mission support is essentially constant

The budget enables a 2018 launch date for Solar Probe Plus without impacting research and analysis support

It maintains the July 2018 launch date for Solar Orbiter

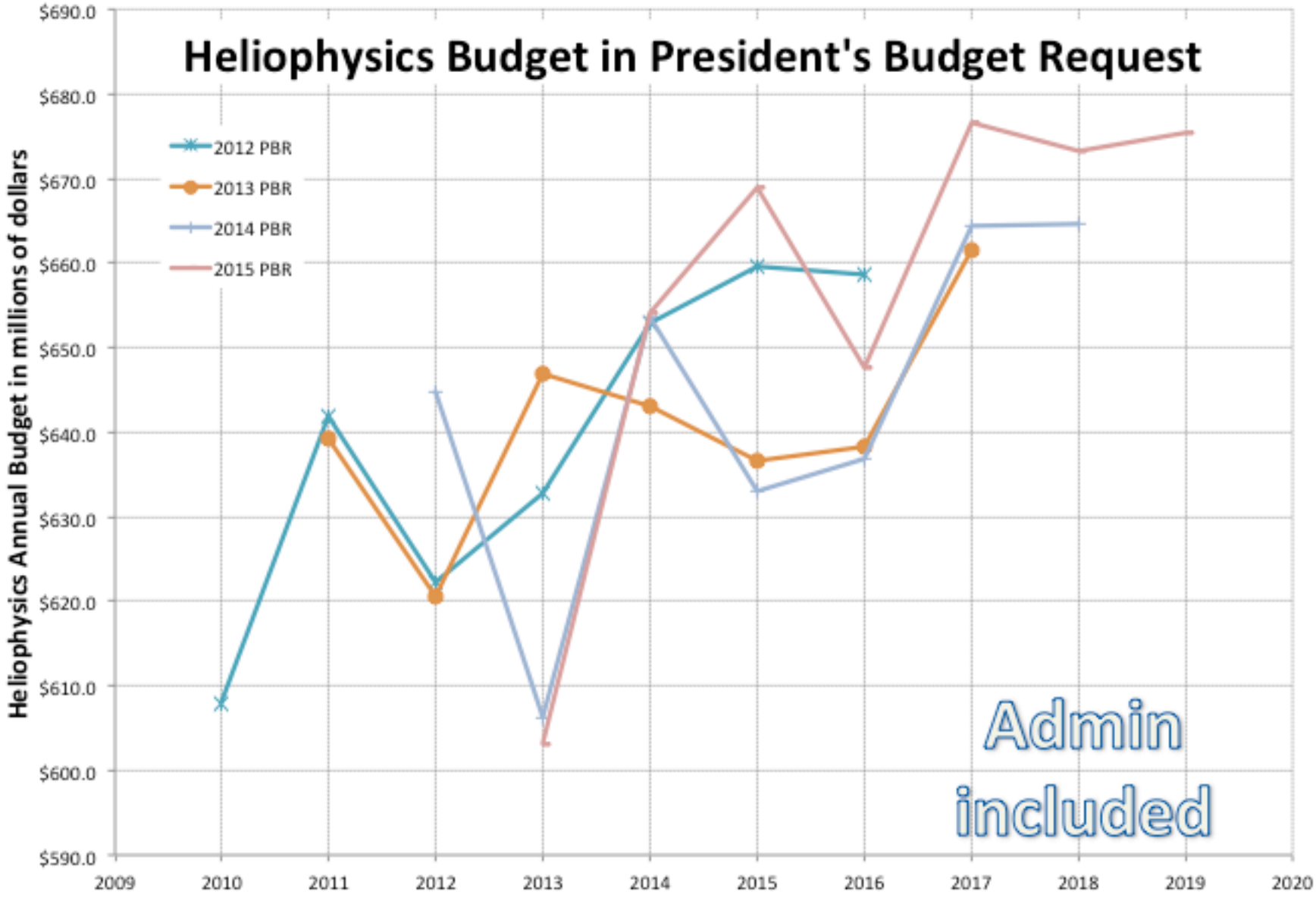
It supports MMS through final integration and test

It funds both ICON and GOLD for launches in 2017

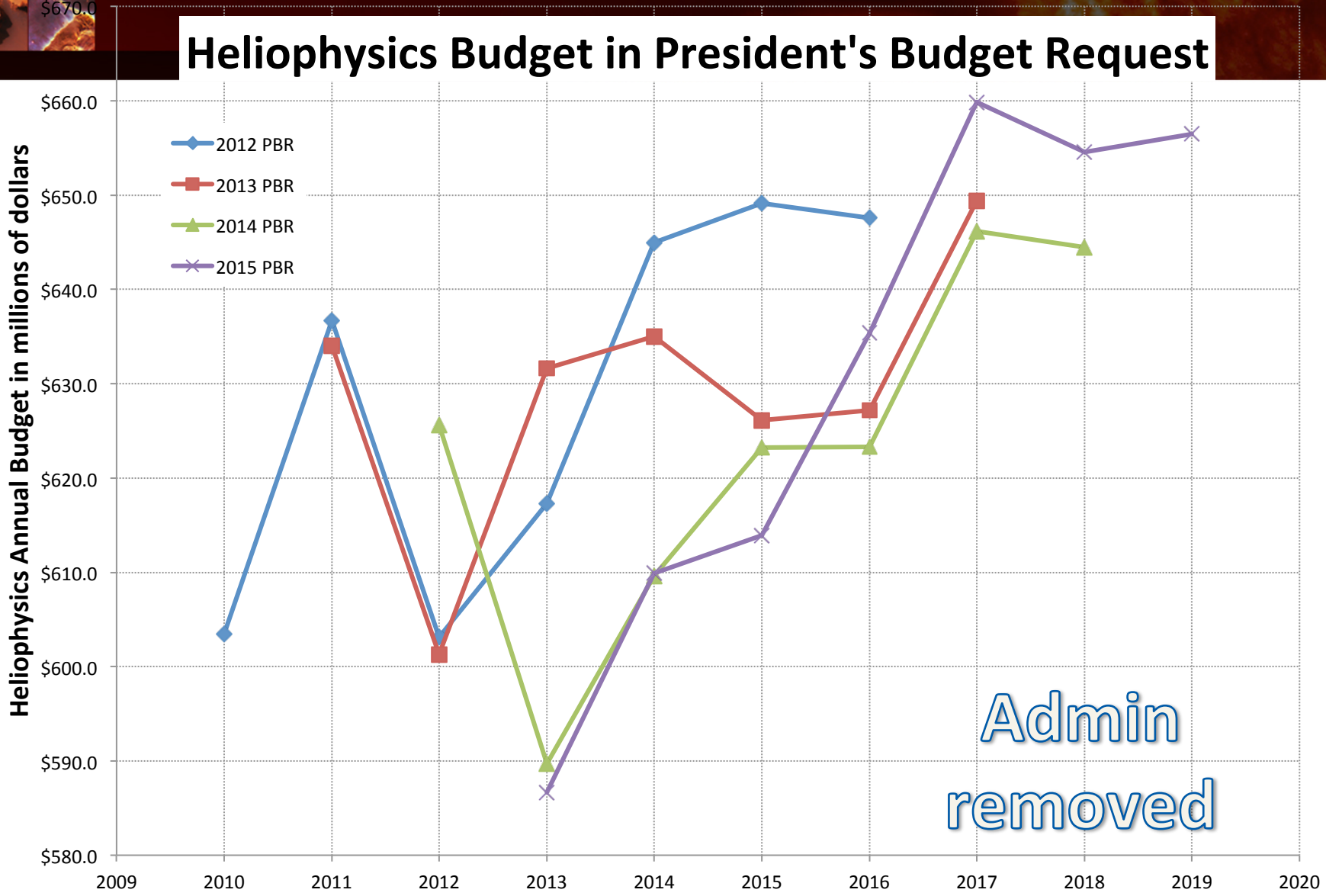
The budget increases cover the SPP cost growth

We will continue to implement the DRIVE initiative

- Small satellites: Addressed with CubeSat budget line item (success)
- Next objective: $10M/yr increase for MO&DA


Heliophysics Budget in President's Budget Request
Heliophysics Annual Budget in millions of dollars
$690.0
$680.0
$670.0
$660.0
$650.0
$640.0
$630.0
$620.0
$610.0
$600.0
$590.0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2012 PBR
2013 PBR
2014 PBR
2015 PBR
Admin included

Heliophysics Budget in President's Budget Request



Heliophysics Budget Details (1 of 3)

FY15 President's Budget Request of 10 March 2014 Budget Authority (in $ millions)	Actual FY 2013	IOP FY 2014	Request FY 2015	Notional FY 2016	Notional FY 2017	Notional FY 2018	Notional FY 2019
Heliophysics Research	165.3	187.401	217.4	158.3	167.6	169.7	169.9
Living with a Star	174.9	212.473	266.4	355.8	378.2	398.9	282.7
Solar Terrestrial Probes	203.9	143.275	61.4	41.5	42.1	30.5	129.4
Heliophysics Explorer Program	59.1	100.199	123.6	91.9	88.7	74.3	93.4
Total Budget	**603.2**	**643.348**	**668.9**	**647.6**	**676.6**	**673.3**	**675.5**
Total budget net of Admin and DR&T	**586.6**	**609.843**	**613.9**	**635.4**	**659.9**	**654.6**	**656.5**
Heliophysics Research	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
Research Range	20.5	21.844	21.3	21.6	21.7	21.7	21.7
Sounding Rockets	56.1	53.383	65.6	48	53	53	53
Heliophysics Research and Analysis	35.1	33.467	33.9	34	33.9	33.9	33.9
Other Missions and Data Analysis	53.5	78.707	96.7	54.6	59.1	61.1	61.4
Total Budget	**165.3**	**187.401**	**217.4**	**158.3**	**167.6**	**169.7**	**169.9**
Total budget net of Admin and DR&T	**148.7**	**153.896**	**162.4**	**146.1**	**150.9**	**151**	**150.9**
Living with a Star	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
Solar Probe Plus	108.2	121.405	145.6	219.2	212.3	345.1	180.4
Solar Orbiter Collaboration	19.1	39.394	76.5	88.8	117.8	6.7	35.4
Other Missions and Data Analysis	47.6	51.674	44.3	47.8	48.2	47	66.8
Total Budget	**174.9**	**212.473**	**266.4**	**355.8**	**378.2**	**398.9**	**282.7**
Solar Terrestrial Probes	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
Magnetospheric Multiscale (MMS)	183.3	120.86	39.5	20.2	12.3	2.7	0
Other Missions and Data Analysis	20.6	22.415	21.9	21.3	29.8	27.8	129.4
Total Budget	**203.9**	**143.275**	**61.4**	**41.5**	**42.1**	**30.5**	**129.4**
Heliophysics Explorer Program	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
ICON	18.2	59.818	78.2	49.8	41	7.5	1
Other Missions and Data Analysis	40.9	40.381	45.4	42.2	47.7	66.8	92.4
Total Budget	**59.1**	**100.199**	**123.6**	**91.9**	**88.7**	**74.3**	**93.4**

Heliophysics Budget Details (2 of 3)

Heliophysics Research OM&DA	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Science Planning and Research Support	5.5	6.346	6.5	6.6	6.7	6.8	6.8
Directed Research & Technology	11.1	27.159	48.5	5.6	10	11.9	12.2
CubeSat	0	5	5	5	5	5	5
SOLAR Data Center	1	1	1	1	1	1	1
Data & Modeling Services	3.5	3.2	3.2	3	3	3	3
Space Physics Data Archive	2	2	2	2	2	2	2
Guest Investigator Program	10.6	8.217	7.2	8	8	8	8
Community Coordinated Modeling Center	1.7	2	2	2	2	2	2
Space Science Mission Ops Services	7.5	10.852	11.3	11.5	11.5	11.5	11.6
Space Weather R2O/Science Data & Computing	0.3	2.3	0	0	0	0	0
Voyager	5.3	5.361	5.4	5.5	5.5	5.5	5.5
SOHO	2.1	2.189	2.1	2.1	2.1	2.1	2.1
WIND	2.1	2	2	2	2	2	2
GEOTAIL	0.5	0.458	0.2	0.2	0.2	0.2	0.2
CLUSTER-II	0.4	0.625	0.2	0	0	0	0
Total Budget	**53.5**	**78.707**	**96.7**	**54.6**	**59.1**	**61.1**	**61.4**
Total budget net of Admin and DR&T	**36.9**	**45.202**	**41.7**	**42.4**	**42.4**	**42.4**	**42.4**

Living with a Star OM&DA	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Balloon Array for Radiation-Belt Relativ	1.9	1.457	0.3	0	0	0	0
LWS Space Environment Testbeds	0.4	0.575	0.6	0.4	0	0	0
LWS Science	20	16.788	17.5	17.5	17.5	17.5	17.5
LWS Program Management and Future Missions	6.1	8.273	5.8	13.1	17.6	20	39.7
Van Allen Probes (RBSP)	7.7	9.818	9.9	6.5	2.5	0	0
Solar Dynamics Observatory (SDO)	11.6	14.763	10.2	10.2	10.5	9.5	9.5
Total Budget	**47.6**	**51.674**	**44.3**	**47.8**	**48.2**	**47**	**66.8**

Heliophysics Budget Details (3 of 3)

Solar Terrestrial Probes OM&DA	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
STP Program Management and Future Missions	1.1	2.179	2.2	1.9	10.7	8.8	110.5
Solar Terrestrial Relations Observatory (STEREO)	8.5	9.5	9.5	9.5	9.5	9.5	9.5
Hinode (Solar B)	8.2	8	7.5	7.3	7	7	7
TIMED	2.8	2.736	2.7	2.7	2.6	2.5	2.5
Total Budget	**20.6**	**22.415**	**21.9**	**21.3**	**29.8**	**27.8**	**129.4**

Heliophysics Explorer OM&DA	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
Global-scale Observations of the Limb and Disk (GOLD)	2.8	9.4	22.1	18.2	15.1	6.2	2.9
Heliophysics Explorer Future Missions	0.1	0	0	0	8.9	39.4	64.5
Heliophysics Explorer Program Management	4.8	3.814	4.1	6.8	7.1	4.7	8.5
Interface Region Imaging Spectogr (IRIS)	15.1	8.615	1	0	0	0	0
Interstellar Boundary Explorer (IBEX)	4	3.6	3.4	3.4	3.4	3.4	3.4
TWINS	1	0.613	0.6	0.6	0.6	0.6	0.6
CINDI	0.9	0.9	0.9	0.6	0.3	0.2	0.2
Aeronomy of Ice in Mesophere (SMEX-9)	3	2.982	3	3	3	3	3
THEMIS	4.4	5.4	5.4	4.6	4.5	4.5	4.5
ACE	3	3	3	3	3	3	3
RHESSI	2	2.057	1.9	1.9	1.9	1.9	1.9
Total Budget	**40.9**	**40.381**	**45.4**	**42.2**	**47.7**	**66.8**	**92.4**

Heliophysics Research Budget Details

Heliophysics Research	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Research Range	20.5	21.844	21.3	21.6	21.7	21.7	21.7
Sounding Rockets	56.1	53.383	65.6	48	53	53	53
Heliophysics Research and Analysis	35.1	33.467	33.9	34	33.9	33.9	33.9
Other Missions and Data Analysis	53.5	78.707	96.7	54.6	59.1	61.1	61.4
Total Budget	**165.3**	**187.401**	**217.4**	**158.3**	**167.6**	**169.7**	**169.9**
Total budget net of Admin and DR&T	**148.7**	**153.896**	**162.4**	**146.1**	**150.9**	**151**	**150.9**

Heliophysics Research OM&DA	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Science Planning and Research Support	5.5	6.346	6.5	6.6	6.7	6.8	6.8
Directed Research & Technology	11.1	27.159	48.5	5.6	10	11.9	12.2
CubeSat	0	5	5	5	5	5	5
SOLAR Data Center	1	1	1	1	1	1	1
Data & Modeling Services	3.5	3.2	3.2	3	3	3	3
Space Physics Data Archive	2	2	2	2	2	2	2
Guest Investigator Program	10.6	8.217	7.2	8	8	8	8
Community Coordinated Modeling Center	1.7	2	2	2	2	2	2
Space Science Mission Ops Services	7.5	10.852	11.3	11.5	11.5	11.5	11.6
Space Weather R2O/Science Data & Computing	0.3	2.3	0	0	0	0	0
Voyager	5.3	5.361	5.4	5.5	5.5	5.5	5.5
SOHO	2.1	2.189	2.1	2.1	2.1	2.1	2.1
WIND	2.1	2	2	2	2	2	2
GEOTAIL	0.5	0.458	0.2	0.2	0.2	0.2	0.2
CLUSTER-II	0.4	0.625	0.2	0	0	0	0
Total Budget	**53.5**	**78.707**	**96.7**	**54.6**	**59.1**	**61.1**	**61.4**
Total budget net of Admin and DR&T	**36.9**	**45.202**	**41.7**	**42.4**	**42.4**	**42.4**	**42.4**

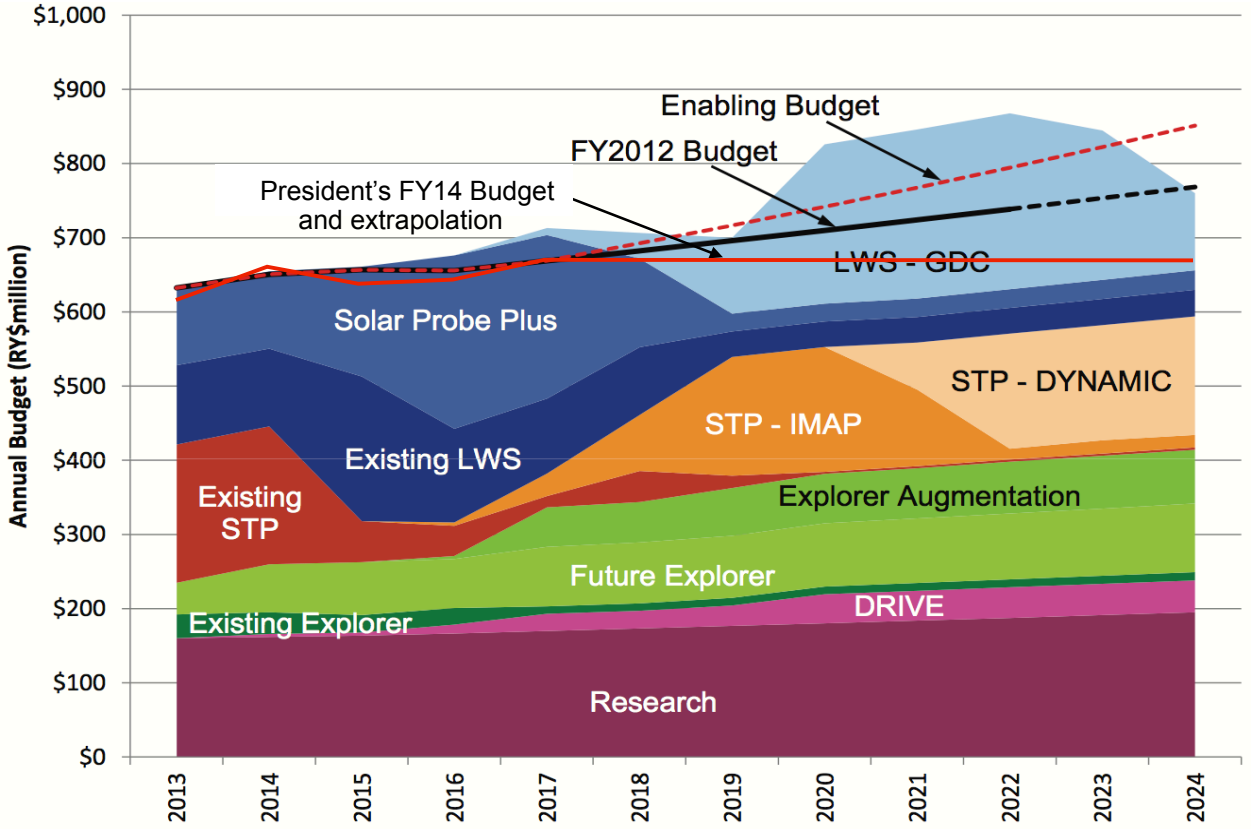
Competed PI Research

Heliophysics Research	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**
Guest Investigator Program	10.6	8.217	7.2	8	8	8	8
LWS Science	20	16.788	17.5	17.5	17.5	17.5	17.5
Heliophysics Research and Analysis	35.1	33.467	33.9	34	33.9	33.9	33.9
Data & Modeling Services	3.5	3.2	3.2	3	3	3	3
Cubesats*	0	1.25	1.25	1.25	1.25	1.25	1.25
Total Budget	**69.23**	**63**	**63**	**63.75**	**63.6**	**63.6**	**63.6**

Topics for discussion

- **NASA's Heliophysics Division Objectives and Organization**
- **Recent Accomplishments, Program Updates, Current Status**
- **Heliophysics Budget Allocations and Projections**
- **Future Planning and Status of Decadal Survey Implementation**
- **Upcoming Key Events, Issues, Discussion**

Decadal Survey Budget Assumptions



- Heliophysics budget and program plan by year and category from 2013 to 2024. (Figure 6.1 from 2013 Decadal Survey, page 6-2)
- President's FY14 budget (solid red line) added, assuming no growth beyond 2018.
- Final FY13 Appropriations totaled $589.7M (after subtracting administrative items)

Decadal Survey Research Recommendations

Recommendations	Science	Cost
0.0 Complete the current Program	Support the existing program elements that constitute the Heliophysics Systems Observatory (HSO) and complete missions in development (RBSP, IRIS, MMS, SOC, SPP).	Assumes no cost growth for any of these elements
1.0 DRIVE (Diversify, Realize, Integrate, Venture, Educate)	Strengthen observational, theoretical, modeling, and technical advances with additional R&A capabilities: small satellites; MO&DA funding augmentation, LCAS augmentation, science centers and grant programs; instrument development	Program rebalance: move up to **~$33M/yr** into Research by 2022
2.0 Accelerate and expand Heliophysics Explorer Program	Launch every 2-3 years, alternating SMEX & MIDEX with continuous Missions of Opportunity.	Program rebalance: move **$70M/yr** extra into Explorers
3.0 Restructure STP line as a moderate scale, PI-led flight program. Implement three mid-scale missions.	Mission 1: Understand the interaction of the outer heliosphere with the interstellar medium; includes L1 space weather observations Mission 2: Understand how space weather is driven by lower atmosphere weather. Mission 3: Understand how the magnetosphere-ionosphere-thermosphere system is coupled and responds to solar forcing.	$520M per mission in FY12$; launches in 2021, 2025, 2029
4.0 Start another LWS mission by the end of the decade.	Mission 4: Study the ionosphere-thermosphere-mesosphere system in an integrated fashion.	$1B mission, Launch 2024

Notes: 1) Recommendations listed above are top level, each contains a number of sub-elements
2) Recommendations are listed in priority order, pending budget constraints
3) Recommendations are separable by Agency, only NASA Recommendations are listed here

Heliophysics Division DS Implementation

- **Execute on our commitments for the current programs:**
  - MMS, Solar Orbiter, Solar Probe Plus, ICON, and GOLD
  - Manage program development risks and opportunities pro-actively
  - Fund operating missions per the 2013 Senior Review
  - Continue formulation and technology development for SPP
    - ❖ Achieve a successful SPP mission confirmation in 2014
- **Implement the Decadal Survey DRIVE recommendations**
  - Grow the Research and Analysis Program as a fraction of total budget
  - Maintain commitments for announced awards and near-term programs
  - Be flexible and innovative in adapting to budget realities
  - Expand and leverage partnerships with NSF, NOAA/SWPC, and others
- **Grow Heliophysics Explorer mission cadence to DS recommendation**
- **Support and facilitate the heliophysics community to demonstrate the importance of heliophysics science and its value to society**
- **Overall objective: Deliver the best possible science program within the budget and following the recommendations of the 2013 Decadal Survey**

Heliophysics Assets Addressing Decadal Priorities

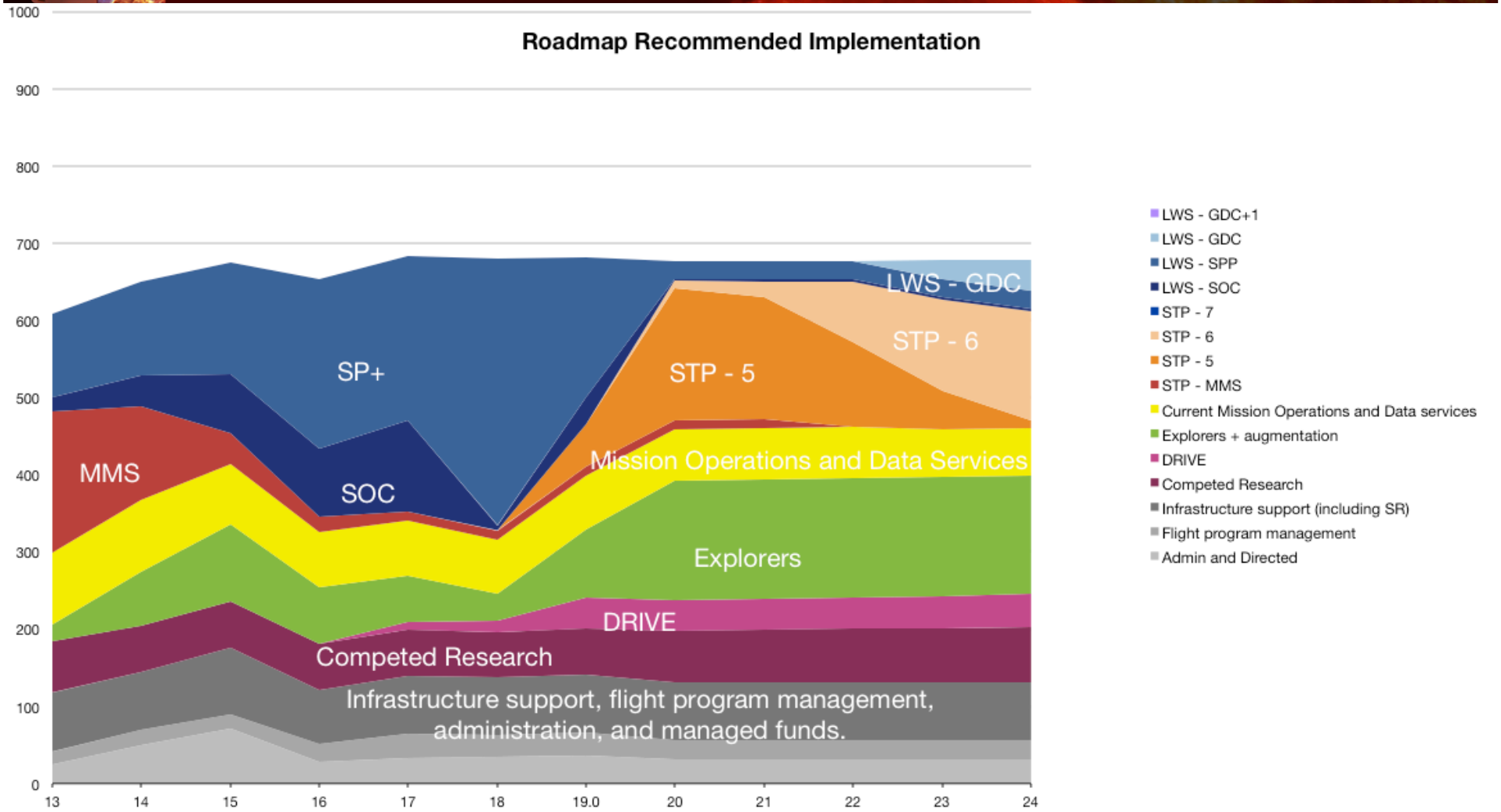
DECADAL SURVEY HELIOPHYSICS SCIENCE GOALS FOR THE NEXT DECADE*	CURRENT HELIOPHYSICS SYSTEM OBSERVATORY MISSIONS	HELIOPHYSICS MISSIONS IN DEVELOPMENT	DECADAL RECOMMENDATIONS
- Determine the origins of the sun's activity and predict the variations in the space environment	IRIS, SDO, STEREO, Hinode, RHESSI, ACE, SOHO, Wind	Solar Orbiter, Solar Probe Plus	DRIVE initiative, Augmented Explorer Program, New Starts: None
- Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs	BARREL, Van Allen Probes, CINDI, TWINS, AIM, TIMED, Cluster, Geotail, Wind, ACE, THEMIS	MMS, ICON, GOLD	DRIVE initiative, Augmented Explorer Program, New Starts: GDC, DYNAMIC, MEDICI
- Determine the interaction of the sun with the solar system and the interstellar medium	IBEX, STEREO, ACE, SOHO, Wind, Voyager	Solar Orbiter, Solar Probe Plus	DRIVE initiative, Augmented Explorer Program, New Starts: IMAP
- Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe	IRIS, Van Allen Probes, SDO, THEMIS/ARTEMIS, STEREO, Hinode, IBEX, RHESSI, Cluster, ACE, SOHO, Wind, Voyager	MMS, Solar Orbiter, Solar Probe Plus	DRIVE initiative, Augmented Explorer Program, New Starts: IMAP, GDC, DYNAMIC, MEDICI

** Heliophysics Research and Analysis, Theory, and Modeling address all goals*

Heliophysics Roadmap

- The Roadmap is the community-generated document to guide NASA HPD's implementation of the Decadal Survey's recommendations
  - Expected to be released within the next few weeks (final draft in final review)
- Closely follows vision and priorities of 2013 Heliophysics Decadal Survey
  - In context of reduced funding for HPD in President's FY14 budget
  - Recognizes and acknowledges need for flexibility in achieving science targets due to significant budget pressures and uncertainties
- Current missions in formulation and development remain the top priority
  - These current missions will require the total available budget until FY18
- NASA planning for longer-term future will depend on:
  - ✓ President's FY14 budget and Congressional actions for FY14 and beyond
  - ✓ President's FY15 budget, released in March 2014
  - ✓ Solar Probe Plus plan and budget, as established at KDP-C
  - Expeditious completion and timely launch of MMS by early 2015
  - ✓ Continued outstanding results and public recognition of heliophysics value

Roadmap 20-Year Budget and Priorities



This is the budget plan provided to guide the Roadmap.
Significant growth in Explorers, fewer large missions.

Heliophysics and DS Recommendations

- **NASA's Commitment (Our HPD Commitment):**
  Achieve as much of the DS priorities as possible, given current budget constraints.

- **Guiding principles:**
  (1) focus resources on the most important and highest quality research,
  (2) utilize the full range of flight opportunities: sounding rockets, cubesats, hosted payloads, etc., and be flexible, to achieve the highest-priority science objectives,
  (3) protect and enhance the core Research and Analysis program,
  (4) seek synergies and partnerships for maximum leverage of scarce resources.

- **Top DS priority: Complete the current program, including ICON and GOLD**
  - Execute on our commitments to the science community and to the taxpayers
  - Manage risks and opportunities as responsible custodians of public trust

- **Support the community to achieve the highest-priority recommendations**
  We must find ways to maximize our current resources and sustain heliophysics science in this restricted budgetary environment. Our ability to understand the Heliophysics System is of growing importance to the science community, to NSF and NASA, and to our Nation. Publicizing program science results and discoveries to an increasingly broad audience will help the public understand why heliophysics is so important.

Topics for discussion

- **NASA's Heliophysics Division Objectives and Organization**
- **Recent Accomplishments, Program Updates, Current Status**
- **Heliophysics Budget Allocations and Projections**
- **Future Planning and Status of Decadal Survey Implementation**
- **Upcoming Key Events, Issues, Discussion**

FY14 Program Accomplishments

✓ • **BARREL**: Balloon campaign #2, Antarctica, in December 2013/January 2014

• **MMS:** Complete observatory integration and testing
  – Successful Pre-ship Review and Operational Readiness Reviews
  – Ship to launch site for successful launch in ~~2014~~ early 2015

• **SPP:** Retire technology development risks, transition formulation to development.
  ✓ – Successful mission PDR in January 2014
  ✓ – KDP-C Confirmation Review in March 2014

• **SOC:** SoloHI and HIS instrument Critical Design Reviews
  ✓ – Launch vehicle procurement and contact awarded

✓ • **GOLD:** Successful System Requirements Review in January 2014
  – Preliminary Design Review in September 2014

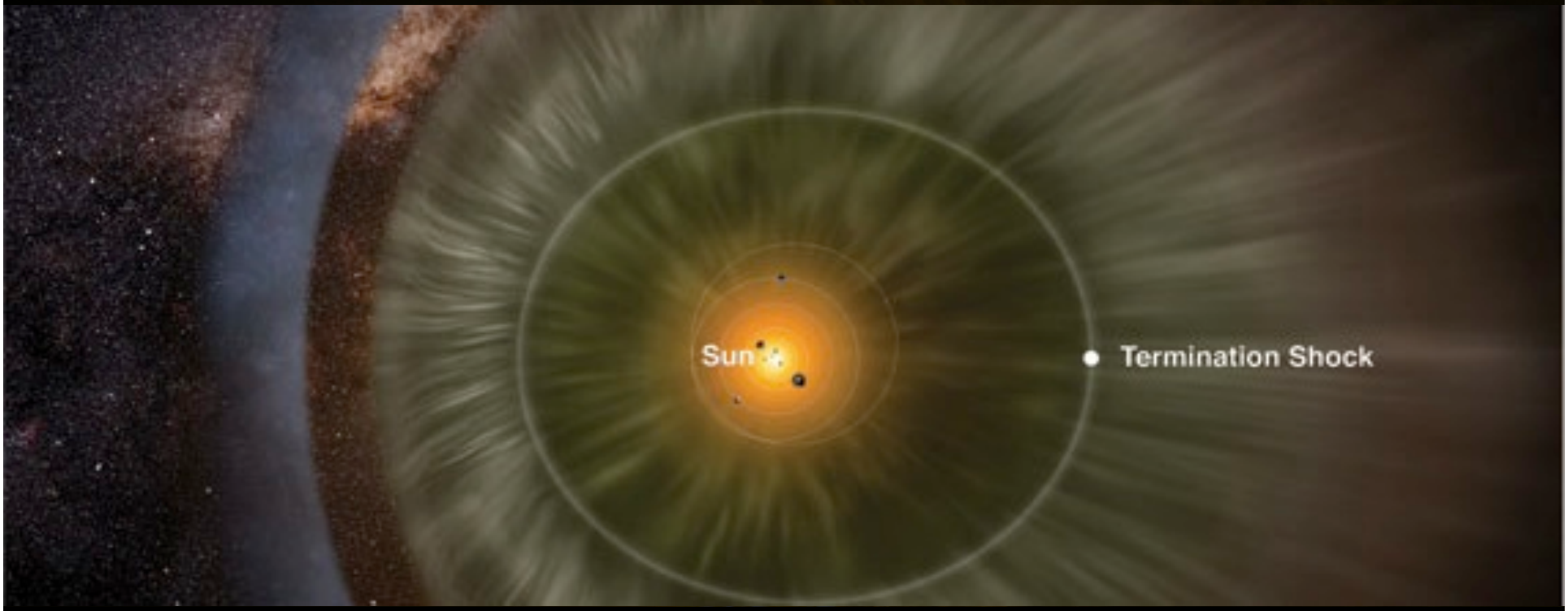
✓ • **ICON:** Successful System Requirements Review in January 2013,
  – PDR in June 2014, Confirmation Review in July 2014

• **R&A:** Enable compelling science addressing key problems in heliophysics

Where is the Heliophysics Division Going?

- **NASA's SMD Heliophysics Division Mission Statement (preliminary draft version):** Use the 2012 Heliophysics Decadal Survey and the Roadmap (soon to be released) as the foundation to foster the next decade of heliophysics research, and to apply its scientific discoveries to provide direct benefits both to the science of space weather and, through its study of fundamental processes and coupled systems, NASA and space science overall.
- **Approach to implementing the Heliophysics Decadal Survey recommendations**
  - Heliophysics Roadmap will define a detailed implementation plan for the Decadal Survey, including technology development requirements
  - Perform on our commitments to complete the current program on time and on budget
  - Strengthen our Research and Analysis, MO&DA, and Technology Programs
  - Plan for more frequent, lower cost missions: Expand Explorers and Missions of Opportunity
  - Commence development of the highest priority Strategic Program (STP, LWS) science targets as soon as possible: Outer heliosphere remote sensing, Geospace coupling
- **Continue to build our understanding of heliophysics (the sun and its interaction with the Earth and solar system) and the science of space weather**

National Aeronautics and Space Administration



Questions?